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An Assessment of Moose (Alces alces americana) and Moose Management in Connecticut

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An Assessment of Moose (*Alces alces americana*) and Moose Management in Connecticut

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Eastern moose (*Alces alces americana*) populations have been increasing in New England over the past decade. Moose populations have the potential to generate human conflict due to their size, speed, nocturnal behavior, and seasonal mobility. As problems associated with increasing moose populations become more common, the need to develop management strategies that are both effective and acceptable to stakeholders becomes increasingly important. The potential for moose to continue to expand in southern New England and the long-term impacts they may have on Connecticut residents, is unclear. The overall purpose of this study was to assess how suitable Connecticut is for moose and respond by developing acceptable and effective strategies for managing future moose populations. Specific objectives were to: 1) determine landscape suitability for moose in Connecticut based on applications of a moose habitat suitability model with temperature constraints; 2) estimate number of moose based on public and hunter sightings; and 3) determine public and hunter attitudes about moose and moose management, and willingness of deer hunters to support various management efforts using mail surveys.

. Data for evaluating landscape suitability were obtained from the United States Department of Agriculture, Forest Service Forest Inventory Database Online; and the Department of Commerce, National Oceanic and Atmospheric Administration's National Climate Data Center Open Geospatial Consortium. Public and hunter sightings were obtained from the Connecticut Department of Energy and Environmental Protection and used to develop population estimates, predict future population growth under various management scenarios, and to validate model outputs. Data on landowner and hunter experiences and opinions about moose were collected using mail surveys and surveys distributed at selected town halls.

Potential number of moose per square kilometer was greatly affected by amount of suitable habitat and ambient air temperatures which varied geographically. Encouraging aggressive forest management practices, such as clear-cutting and shelter wood cutting in northern Connecticut, would be beneficial for moose. Connecticut's moose population was conservatively estimated at 73 in 2008. Although unlikely, the moose population potentially could grow exponentially in the next 20 years. If the moose population expands as predicted by the model, it would be valuable to establish a limited moose hunting season sooner rather than later to minimize potential human-moose conflicts. At present, the majority of landowners and hunters believe < 100 moose exist in Connecticut and most think the population is too low, but believe it is increasing. Support for hunting by landowners initially was low, but increased as potential concerns, especially related to moose-vehicle accidents increased. Support for hunting by hunters was high.

We expect a reduction in the public's tolerance for moose given further conflicts. The need for increased public education, e.g. the role of lethal management to protect humans, and being proactive rather than reactive, will be critical for successful moose management in Connecticut. Most hunters were supportive of using moose hunting to control population growth, but would prefer restrictions on the harvest of cow moose and permit availability. Hunter insight was valuable from a management perspective for determining which geographic areas should be considered for hunting, timing and length of seasons, equitable hunter selection processes, and methods of hunting acceptable to hunters.

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I thank Howard Kilpatrick and John Barclay for providing me the opportunity to conduct this research and pursue my M.S. degree, and reviewing all chapters in this thesis. I thank Dale May and Greg Chasko for supporting this effort and reviewing all surveys. I thank my dad for introducing me to the outdoors and sparking my interest in pursuing a lifelong dream of working in the environmental field and both my mom and dad for being great supporters of my endeavors. Without the support and patience of my wife Kristen and daughter Elizabeth, completion of this effort would not have been possible.

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Chapter 1

Introduction

Problem Statement

The moose (*Alces alces)* is one of the largest land mammals in North America (Franzmann 1980) and is considered a renewable resource that provides some intrinsic economic value to both consumptive and non-consumptive users (Schwartz and Bartley 1991). However, populations that reach levels where recreational opportunities exist can also produce adverse consequences in the form of ecological damage (Timmermann and Rodgers 2005, Faison 2006) and moose-vehicle accidents (MVA), which create challenges for wildlife managers (Alexander 1993, Boyle et al. 1993, Danks and Porter 2010, DeStafano and Wattles 2010). In Michigan, moose browsing prevented sapling regeneration and altered the balance of the forest ecosystem (McInnes et al. 1992). Preliminary assessments of moose effects on forest regeneration in Massachusetts suggest that moose, even at low densities, are having localized effects and may be changing species composition (Faison 2006, Faison et al. 2010).

As moose populations increase, the likelihood of motorists being involved in a potentially fatal MVA also increases (Alexander 1993, DeStafano and Wattles 2010). As Vermont's moose population expanded from the early 1980s to the early 1990s the number of moose vehicle accidents increased from a one or two per year to more than 60 per year (Alexander 1993). In Maine, where more than 600 moose-vehicle accidents occur annually at an estimated cost of $20 million, about three human fatalities a year result from motorists hitting a moose (Danks and Porter 2010, Maine Department of Motor Vehicles, personal communication). In Massachusetts, the population of moose and the number of moose-vehicle accidents has increased greatly in the past several years with two resulting in a human fatality (DeStafano and Wattles 2010). Since the first moose-vehicle accident occurred in 1995, Connecticut has experienced an average of 1.5 moose-vehicle accidents per year with one resulting in a human fatality (H. Kilpatrick, Connecticut Department of Energy and Environmental Protection, Wildlife Division, personal communication).

Moose populations in northern New England expanded in the mid-to-late 1900s from improved habitat conditions and laws protecting moose from over hunting (Alexander 1993, Vashon 2008). As moose populations expanded in Vermont, public meetings were held and a management plan was developed to provide for the welfare of the moose population while addressing interests and concerns of the public (Alexander 1993). Regulated hunting seasons have been established in Maine, New Hampshire, and Vermont (Alexander 1993, Alexander et al. 1998, Vashon 2008, Snyder and Rines 2010) to allow for regulated use of a natural resource and to address public concerns related to increasing moose populations. Increasing moose populations in northern New England have contributed to moose expansion into southern New England (Kilpatrick et al. 2003).

In Massachusetts and Connecticut, state statute or regulations prohibit hunting moose, therefore the only available options for handling moose are through monitoring and hazing, immobilization, relocation, and euthanization (Vecellio et al. 1993, Kilpatrick et al. 2003, McDonald 2004). If moose populations in southern New England continue to expand, additional management actions may need to be explored (McDonald 2004).

Little information exists about landscape suitability for moose, how many moose exist, and where population expansion is most likely to occur in Connecticut. No information exists about public and hunter perceptions of moose, or support for potential moose management in Connecticut. Evaluating landscape suitability for moose, size of the current moose population, and the expected rate of growth and expansion of moose in Connecticut will be advantageous. If the moose population expands and problems associated with increasing moose populations become more common, understanding perceptions about moose and interest in moose management will be essential for developing management strategies that are both effective and acceptable to the public and hunters.

Introduction and Justification

The moose is the largest member of the deer family (up to 635 kg), and is one of the tallest land mammals in North America (standing 1.8 m at the shoulder) (Franzmann 1980, Bubenik 2007). Moose are believed to have arrived in North America from Siberia via the Bering land bridge during the last ice age 10,000–14,000 years ago (Bowyer et al. 2003, Hundertmark et al. 2003, Bubenik 2007). Historical distributions of moose in North America have been associated with glacial epochs, boreal forests (Franzmann 1980), and burned or disturbed lands where woody vegetation regenerates rapidly (Peek 1997, Maier et al. 2005).

In North America four distinct sub-species of moose are recognized by taxonomists. Northwestern moose (*A. a. Andersoni*) range from the Great Lakes north and west to the Pacific coast to the Yukon Territory. Alaskan moose (*A. a. gigas*), the largest subspecies, range throughout the western Yukon Territory, northern British

Columbia and Alaska. Shira's moose (*A. a. shirasi*) range from the northern Rockies into southern Alberta and British Columbia. Eastern moose (*A. a. americana*) are found in the northeastern United States and eastern Canada (including Newfoundland), westward to the Great Lakes, and are the focus of this research.

With the retreat of the continental glaciers, northern moose populations began expanding further north to inhabit portions of North America previously unoccupied (Franzmann 1980, Bowyer et al. 2003, Hundertmark et al. 2003, Bubenik 2007). During the 1800s moose populations declined or were extirpated from much of the eastern U.S. (Goodwin 1935, Boer 1992, Alexander 1993, Vecellio et al. 1993, Murray et al. 2006). In northern New England (Maine, Vermont, and New Hampshire), moose were abundant in the 1600s (Alexander 1993). By the 1800s they had declined considerably due to habitat loss and unregulated hunting (Alexander 1993, Vashon 2008, Snyder and Rines 2010). In southern New England, moose were extirpated from Massachusetts in the 1800s (Vecellio et al. 1993) and it is unclear whether moose were ever native to Connecticut (Trumbull 1797, Goodwin 1935, N. Bellantoni, Connecticut State Archeologist, personal communication). In Connecticut, no archaeological deposits of moose have been documented (N. Bellantoni, personal communication). However, Trumbull (1797) reported that in the 1600s, plenty of moose were found. However at the beginning of the eighteenth century there were no records of moose in Connecticut (Goodwin 1935), indicating that moose, if native, likely existed in low numbers.

Moose populations in northern New England expanded in the mid-to-late 1900s from improved habitat conditions and from laws protecting moose from excessive hunting (Alexander 1993, Vashon 2008). As moose populations expand, the potential to generate human conflict due to their size, speed, nocturnal behavior, and seasonal mobility increases (Mirick 1999). With an average home range of 25.9 square kilometers (Cederlund and Sand 1994), moose have the potential to be serious road hazards in human-developed areas. Regulated hunting seasons were established in Maine (1980), New Hampshire, (1987), and Vermont (1993) to allow for use of moose as a sustainable natural resource and to address concerns about increasing populations (Alexander 1993, Vashon 2008). By 2008, the moose population in northern New England exceeded 40,000 (Alexander et al. 1998, Vashon 2008, Snyder and Rines 2010). Unlike past northerly expansions, increasing moose populations in New England began expanding southward into Massachusetts and Connecticut (Vecellio et al. 1993, Kilpatrick et al. 2003).

Massachusetts experienced an increase in public reports of moose and moose-vehicle accidents during the past two decades (Vecellio et al. 1993, DeStafano and Wattles 2010). Massachusetts, which is the third most densely human populated state in the United States, has an estimated 800-1,800 moose (DeStefano and Wattles 2010) and with no hunting season, the population can be expected to continue increasing.

During the 1900s moose sightings in Connecticut were sporadic (Connecticut Wildlife 2000, Kilpatrick et al. 2003). However, since 2000, reports of credible sightings of cows with calves by the public and hunters, confirmed establishment of a residential moose population in Connecticut (Kilpatrick et al. 2003). Based on public sightings of moose, the population was estimated conservatively at about 64 moose in 2006 (LaBonte and Kilpatrick 2006).

Since the first reported moose-vehicle accident occurred in 1995, Connecticut has experienced an average of 1.5 moose-vehicle accidents per year (H. Kilpatrick, personal communication). In 1998, the Wildlife Division adopted a directive outlining procedures for responding to problem moose (DEEP2431-D1). Responses to actual situations included hazing, capture and relocation, and euthanasia. Because of concerns about spread of Chronic Wasting Disease, relocating moose out-of-state was prohibited in 2003 (Connecticut Department of Agriculture Regulations Sec. 22-278-6). If the moose population continues to expand, problems with moose will increase and other management strategies may need to be developed.

Moose populations in southern New England potentially are limited by four factors: habitat, climate, disease, and urban development/human tolerance. Understanding how various environmental factors may affect moose population expansion and distribution in Connecticut is important for developing effective population models. Baseline data on landscape suitability and population dynamics of moose in Connecticut are lacking. Few studies have assessed environmental influences on moose populations at the southern extent of their range (Murray et al. 2006, Lenarz 2009).

In southern New England, selective timber harvesting practices are the most widespread forms of habitat disturbance other than urban development. Active forest practices trigger regeneration (Kittredge et al. 2003), and may influence how moose use Connecticut's landscape. Developing a habitat suitability model could be beneficial in understanding potential for moose to exist in the state and potential for population expansion to occur in the future.

Several researchers also have noted that climate may greatly affect moose population dynamics, as thermoregulation thresholds for moose can be exceeded in the southern portions of their range (Create and Courteois 1997, Gaillard et al. 2000, Murray et al. 2006, Lenarz 2009). High temperatures can lead to heat stress and eventually death (Create and Courteois 1997, Gaillard et al. 2000, Murray et al. 2006, Lenarz 2009), and may be an additive factor limiting moose populations in Connecticut.

Liver flukes (*Fascioloides magna*) and meningeal worms (*Parelaphostrongylus tenuis*), associated with white-tailed deer, are known to affect the frequency of disease in moose where ranges overlap (Gilbert 1974, Whitlaw and Lankester 1994, Dumont and Crete 1996, Murray et al. 2006). A recent study on the causes of moose population decline in Minnesota found that parasites (liver flukes and meningeal worms) were responsible for up to 62% of moose deaths (Murray et al. 2006). White-tailed deer densities in Connecticut vary greatly across the landscape (2-12 deer/km^2, Gregonis 2007), but the role deer and disease may play in the dynamics of the moose population at the southern extent of their easterly range is unknown.

If environmental factors are not a major limiting factor affecting moose at the southern extent of their range, an increasing moose population will present new challenges for wildlife managers who need to balance the conservation of resources and the satisfaction of the stakeholders who use them (Boyle et al. 1993). Moose have tolerated human settlement and activity (Telfer 1984). However, it is unclear how tolerant humans in southern New England will be of moose. Except for Alaska (Fulton and Hundertmark 2004) and Canada (Wedeles et al. 1989, Hansen et al. 1995, Ericsson 2003), limited human dimensions research related to moose has been conducted. In the northeast, Lauber and Knuth (1997, 1999) evaluated how citizens perceived the process by which reintroduction of moose into the northern Adirondacks of New York was decided, and measured citizen opinions about the reintroduction. In New Hampshire, Donnelly and Vaske (1995) examined the influence of different variables on resident reactions to a specific wildlife management proposal, while Alexander (1993) evaluated public opinions about moose and proposed moose management at public meetings in Vermont.

Understanding stakeholder attitudes is important when developing outreach and management programs and the need to balance stakeholder preference with agency objectives (Teel et al. 2002). Incorporating stakeholder opinions into the decision-making process should improve public acceptance, improve implementation of management plans (Flanigan 1987, Hartig and Thomas 1988, Pinkerton 1991, Landre and Knuth 1993), strengthen relationships between agencies and the public (Landre and Knuth 1993), and reduce conflict (Erickson 1979, Twight and Patterson 1979, Nelkin 1984, Blahna and Yonts-Shepherd 1989).

Currently, little information exists about stakeholder perceptions of moose and moose management as they pertain to moose at the southern extent of their range. As problems associated with increasing moose populations become more common, the need to develop management strategies that are both effective and acceptable to stakeholders becomes increasingly important. The potential for moose to continue to expand in southern New England, and the long-term impacts moose may have on residents is unclear.

Understanding public and hunter opinions about moose and moose management will be essential for development of a moose management plan that will be effective at addressing public, hunter, and agency concerns in Connecticut. Human dimension surveys related to moose, specifically those of hunters, have aided managers in making informed management decisions regarding season dates, selective harvest systems, quotas, and regulation changes (Wedeles et al. 1989, Hansen et al. 1995, Fulton and Hundertmark 2004).

The purpose of this study was to: 1) determine landscape suitability for moose in Connecticut based on applications of a moose habitat suitability model with temperature constraints; 2) estimate number of moose based on public and hunter sightings; and 3) determine public and hunter attitudes about moose and moose management, and willingness of deer hunters to support various management efforts using mail surveys.

Objectives and Hypotheses

1) Determine landscape suitability for moose in Connecticut.
    a. H_o: Landscape suitability for moose will be equal across the state.
    b. H_a: Landscape suitability for moose will be different across the state.
2) Determine the effectiveness of different management strategies on moose population growth through population modeling.
    a. H_o: All management strategies have similar effects on moose population.
    b. H_a: All management strategies have different effects on moose population.
3) Determine landowner and hunter attitudes about moose and moose management in Connecticut.
    a. H_o: Landowner experiences, perceptions, and opinions of moose and moose management are similar in one or more regions.

b. $\boldsymbol{H_a}$**:** Landowner experiences, perceptions, and opinions of moose and moose management are different in one or more regions.

c. $\boldsymbol{H_o}$**:** Landowner and hunter perceptions of moose and moose management are similar.

d. $\boldsymbol{H_a}$**:** Landowner and hunter perceptions of moose and moose management are different.

4) Determine deer hunter perceptions, attitudes, and willingness to use lethal management strategies.

   a. $\boldsymbol{H_o}$**:** Factors that will influence deer hunter perceptions and attitudes about moose will be similar

   b. $\boldsymbol{H_a}$**:** Factors that will influence deer hunter perceptions and attitudes about moose are not similar.

Thesis Organization

This thesis consists of six chapters, four of which are intended for publication in peer-reviewed scientific journals. Chapter 1 includes a general introduction that provides background information and my research objectives. Chapters 2, 3, 4, and 5 are in the format required for submission to appropriate scientific journals. Chapter 6 includes general conclusions from my research and provides recommendations for management and future research.

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CHAPTER 2

MODELING LANDSCAPE SUITABILITY ALONG THE SOUTHERN EXTENT OF MOOSE RANGE

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ABSTRACT: Wildlife habitat models are useful tools for predicting attributes of a wildlife population. The most widely accepted wildlife habitat modeling system for moose was developed by the United States Fish and Wildlife Service and relies on the development of a Habitat Suitability Index (HSI). It has been suggested that high temperatures reduce reproductive performance and may restrict the expansion of moose populations into areas with otherwise adequate habitat. We used the HSI model combined with summer and winter temperature restrictions to predict landscape suitability and the potential number of eastern Moose (*Alces alces americana*) in Connecticut. HSI values in Connecticut ranged from 0.09 to 0.44, while the number of moose per square kilometer ranged from 0.2 to 0.9. Total potential moose in Connecticut (1,406), based on HSI, potential moose habitat, and moose densities derived from our landscape suitability output, varied geographically across the state. Average daily temperatures in Connecticut exceeded temperature thresholds for moose at various locations 56-82% of the year. Eighty-six percent of towns with > 10 moose sightings were within the areas with the highest landscape suitability. Reported public and hunter sightings were valuable in validating output from our landscape suitability output. Limited moose habitat and high ambient temperatures likely are major limiting factors for moose populations in Connecticut. Knowledge gained from a simple modeling exercise will allow managers to make more informed decisions about moose and moose management.

KEY WORDS: *Alces alces americana*, Habitat Suitability Index, moose, temperature, sightings

Alces 00(0):000–20XX

Wildlife habitat models are useful tools for predicting attributes of a wildlife population. Several habitat suitability models for moose (*Alces alces*) have been developed over the years with varying degrees of sophistication (Allen et al. 1987, Dettki et al. 2003, Dussault et al. 2006). The most widely accepted wildlife habitat modeling system for moose was developed by the United States Fish and Wildlife Service and relies on the development of a Habitat Suitability Index (HSI) (Allen et al. 1987). Available data and expert opinions were used to develop models that predict the suitability of habitats for moose based on a small number of variables (Allen et al. 1987). Allen et al. (Ibid.) developed 2 versions of the HSI model for eastern moose (*Alces alces americana*) in the Lake Superior region.

The first model was based on evaluations of the abundance and quality of growing and dormant–season food and cover. Optimal habitat has been described as areas dominated by early-successional vegetation offering a wide variety of stand types and age classes that provide both mature conifer cover and open disturbed areas for forage production (Telfer 1978, 1984). The second model was based on evaluations of cover type composition and its assumed relationship to moose habitat suitability in the region of interest. Optimum cover type composition was shrub and forested cover types <20 years old is 40%, coniferous forest > 20 years old is 5%, upland deciduous/mixed forest ≥ 20 years old is 50%, and suitable wetland 5% (Allen et al. 1987). Both models were based on the assumption that moose populations that have an abundance of quality food and cover have the potential to increase or stabilize at relatively high densities (Jordan and Wolfe 1980, Peterson and Page 1983) in the absence of critical mortality factors. Both models estimate potential moose density using a maximum HSI value of 1, suggesting that the landscape has the potential to support 2 moose/km^2 (Allen et al. 1987). Lower HSI values indicate a capacity to support correspondingly fewer moose.

Kelsall and Telfer (1974) and Telfer (1984) noted that the southern limit of moose distribution corresponded closely to the 20°C July isotherm. Kelsall and Telfer (1974) speculated that high temperatures may reduce reproductive performance, limiting the southern expansion of moose, even though adequate habitat may exist. Moose have difficulty dissipating surplus heat during warm temperatures which can lead to heat stress (Renecker and Schwartz 2007). During summer, thermal stress for moose begins when ambient air temperatures approach 14°C and open mouth panting begins at 20°C (Renecker and Hudson 1986, 1990). During winter/spring, moose can experience heat stress when temperatures rise above -5°C (Renecker and Hudson 1986, 1990). The high-energy cost of heat stress can lead to reductions in overall activity, influencing feeding time and consumption rates, and can result in weight loss (Renecker and Schwartz 2007).

Koitzsch (2002) suggested that HSI models that incorporate some heat stress variable that quantifies number of days and number of hours per day temperatures exceeded heat stress thresholds for moose would enhance the accuracy of the HSI model along the southern limit of moose range. No studies have evaluated both habitat suitability and temperature limitation on moose distribution. Our objectives were to determine the landscape suitability for moose along the southern extent of moose range, based on Allen's HSI model (1987), adjusted for heat stress conditions, and determine the number of days temperatures exceeded heat stress levels. Landscape suitability output was validated using public and hunter moose sightings.

STUDY AREA

The study area was the state of Connecticut (12,548.5 km^2) which was the fourth most densely populated state (3,500,000 people (278 people/ km^2)) in the United States (Connecticut Economic Resource Center 2006, 2010). Located in southern New England, Connecticut is bounded on the south by Long Island Sound, and by the states of Rhode Island to the east, Massachusetts to the north, and New York to the west. Connecticut was primarily forested (56%), 20% developed or barren, 17% turf, grass or agricultural field, 4% wetlands (non-forested, forested, and tidal), and 3% water (Hochholzer 2010). Tree species comprising Connecticut forests by net volume are, red maple (*Acer rubrum*) (21%), red oak (*Quercus rubra*) (14%), white pine (*Pinus strobus*) (8%), black oak (*Quercus velutina*) (7%), black birch (*Betula lenta*) (7%), white oak (*Quercus alba*) (7%), eastern hemlock (*Tsuga canadensis*) (5%), white ash (*Fraxinus americana*) (5%), sugar maple (*Acer saccharum*) (4%), scarlet oak (*Quercus coccinea*) (4%), and various other species (18%) (Hochholzer 2010). Seventy-eight percent of

Connecticut forests are considered mature (trees > 60 years old) with few (2.7%) age classes <20 years old (Hochholzer 2010). Mean annual temperature for Connecticut in 2008 was 9.7°C and annual precipitation was 161.3cm (United States Department of Commerce, National Oceanic and Atmospheric Administration 2008). Eichenlaub (1979) and Koitzsch (2002) concluded that climate in the Lake Superior region and New England was similar based on vegetation type, temperature, and precipitation. Therefore, we considered it appropriate to assess moose habitat in Connecticut using the HSI model developed by Allen et al. (1987).

Historic accounts suggest that moose existed in Connecticut prior to the eighteenth century (Trumbull 1797, DeForest 1964). However, Goodwin (1935) noted that at the beginning of the eighteenth century there were no records of moose in Connecticut. According to the Connecticut State Archaeologist, no archaeological deposits of moose have been found (N. Bellantoni, Connecticut State Archeologist, personal communication) indicating that moose, if ever native, likely existed in low numbers.

Between 1916 and 1956 sightings of moose in Connecticut were reported by the public on a few occasions (Connecticut Wildlife 2000). On 18 September 1956 the Connecticut Board of Fisheries and Game, now the Connecticut Department of Energy and Environmental Protection (DEEP), passed an emergency regulation that gave full protection to moose found in Connecticut. From the 1980s to the early 1990s wandering moose occasionally were reported in the state; however, there was no evidence that a resident population existed in Connecticut (Kilpatrick et al. 2003). In 1992, the DEEP began documenting all credible public moose sightings and moose-vehicle accidents, and in 1996, a question was added to the annual deer hunter questionnaire asking hunters to report all sightings of moose during the hunting season. In 1998, the Connecticut DEEP, Wildlife Division, adopted a directive (DEEP2431-D1) that outlined procedures for responding to problem moose situations in Connecticut that included hazing, capture and relocation, and euthanization. Since 2000, reports of cows with calves confirmed the establishment of a resident moose population and public sightings suggested Connecticut's moose population was expanding in size and distribution (Kilpatrick et al. 2003).

METHODS

Amount of potential moose habitat was determined using ArcGIS 9.2 (ESRI, Redlands, CA, USA) and land cover maps (2002) obtained from the University of Connecticut's Center for Land Use Education and Research (CLEAR). Land cover maps were delineated into 11 cover types by CLEAR (developed, turf & grass, other grasses & agriculture, deciduous forest, coniferous forest, water, non-forested wetland, forested wetland, tidal wetland, barren, and utility rights-of-way) using 30m by 30m pixels classified using the most prevalent spectral signature. Using ArcGIS, we divided land cover maps using the 8 county boundaries. Each county was reclassified into areas of "potentially suitable" and "non-suitable" moose habitat. Non-suitable moose habitat was considered high-density built-up areas typically associated with commercial, industrial, and highly developed residential areas with little pervious surface (developed) and non-agricultural areas free of vegetation (barren). Moose dispersing into counties with >25% non-suitable habitat were removed (H. Kilpatrick, Connecticut Department of Energy and Environmental Protection, Wildlife Division, personal communication) due to public safety risk associated with moose in highly developed areas and were classified as "unsuitable." The towns of Canton, Burlington, Granby, and Hartland are in a county with >25% developed lands, but were not considered unsuitable because relatively little development existed (≤13%) in those towns, they border a county with potentially suitable habitat, and moose existing in those towns were not selected for removal by the DEEP (Ibid.).

We used the second HSI model developed by Allen et al. (1987), based on an evaluation of cover type composition, to evaluate landscape suitability for moose. Habitat data by county were obtained from The United States Forest Service, Forest Inventory Data Online (FIDO 2008). Classification types used were percent area in small diameter (Suitability Index Value, SIV10), percent area in conifer > 20 years old (SIV11), percent area in upland deciduous or mixed > 20 years (SIV12), and percent area in wetlands (SIV13). The HSI = $(SIV10 \times SIV11 \times SIV12 \times SIV13)^{1/4}$. Moose habitat in Connecticut was classified into least suitable (HSI = 0.0-0.31), suitable (HSI = 0.32-0.66), and most suitable (HSI = 0.67-1.0) following Koitzsch (2002) and Hickey (2008). Number of moose/km^2 was derived by multiplying the potential maximum number of moose/km^2 (2), by the HSI value.

Mean daily average temperatures and geographic delineations for each month were obtained from the Department of Commerce, National Oceanic and Atmospheric Administration's (NOAA) National Climate Data Center (NCDC) Open Geospatial Consortium (OGC) for Connecticut in 2008. The NCDC data were categorized into 8 temperature ranges (<-6.67, -6.67-0.0, 0.1-4.4, 4.5-10.0, 10.1-15.5, 15.6-21.1, 21.2-26.60, 26.7-32.2°C) and were delineated on a digitized map of Connecticut in ArcGIS 9.2

(ESRI, Redlands, CA, USA). We determined the temperature suitability for moose using 3 temperature classifications: most suitable (mean March temperatures < 0.0°C and July temperatures < 21.1°C), suitable (mean March temperatures > 0.0°C and July temperatures < 21.1°C), least suitable (mean March temperatures > 0.0°C and July temperatures > 21.1°C).

We used output from our habitat suitability model and temperature suitability to evaluate landscape suitability (LS) based on town (Burlington, Canton, Granby, and Hartland), and county boundaries. Moose densities were calculated for all suitable habitats in Connecticut based on the HSI model output. Moose densities were then weighted using a multiple of 0.5, at each change in temperature suitability to calculate the potential number of moose for each area.

To validate our landscape suitability results, we calculated total public and hunter moose sightings received by the DEEP, Wildlife Division, between 1992-2008 for each Connecticut town. Towns with ≥ 3 moose sightings over a 15-year period were used to generate a density-distribution map. Cow/calf sightings received by the DEEP, Wildlife Division from 2000-2008 were also used to validate our landscape suitability results.

Similar to Koitzsch (2002), we calculated the number of days that mean temperatures exceeded critical levels for moose (20°C between May and September when moose are in summer pelage, and -5°C between October and April when moose are in winter pelage) using daily temperature data from 11 weather stations (Wenqiang Bao, Connecticut State Climate Center, University of Connecticut, College of Agriculture and Natural Resources, personal communication) for 2008.

A GPS radio-collar (Telemetry Solutions, Concord, California) with a temperature sensor was placed on an adult bull moose by the DEEP in 2009 in the town of Hartland, which historically had the greatest amount of moose activity (Kilpatrick et al. 2003). Temperature readings recorded from the collar between 1 February – 11 December, 2009 were used to further evaluate exposure to high temperatures in an area where it appears moose have persisted for the greatest period of time in Connecticut.

RESULTS

Percent area in small diameter was the most limiting variable in the HSI model input for all counties (Table 2.1). A HSI was calculated for 7 Connecticut counties and ranged from 0.09 to 0.44. Corresponding moose density ranged from 0.2 to 0.9 moose/km^2 (Table 2.1). Total potential moose population in Connecticut (1,406), based on landscape suitability, varied geographically across the state (Table 2.2, Figure 2.1).

A total of 879 moose sightings from the public and hunters were received between 1992 and 2008. Eighty-six percent of towns with > 10 moose sightings were within the areas with the highest landscape suitability (LS1-5) (Figure 2.2). All but one cow/calf sighting was within the areas with the highest landscape suitability (LS1-5) (Figure 2.3). Average daily temperatures in Connecticut exceeded temperature thresholds for moose 203 (56%) to 299 (82%) days in 2008 at 11 weather stations distributed across the state (Table 2.3, Figure 2.4). Temperature readings distributed throughout the year (n = 2,489) recorded from the GPS collared moose in northwest Connecticut revealed that the moose was exposed to average summer temperatures 4°C above stress threshold temperatures (20°C) 81% of the time and was exposed to average winter temperatures 14.7°C above winter stress threshold temperatures (-5°C) 96% of the time.

DISCUSSION

Our landscape suitability analysis confirms that much of the landscape along the southern extent of current moose range is classified as “least suitable”, which may limit future expansion of moose in Connecticut. Telfer (1978), and Collins and Helm (1997), indicated that the abundance of regenerating forest is often the most limiting factor of moose density. From our analysis, percent of area with small diameter trees (SIV10) appears to be having the greatest effect on HSI values and may be limiting suitable habitat for moose in Connecticut. Hochholzer (2010) noted that Connecticut forests are not well balanced in terms of either size or age class and recommended a greater effort be invested in promoting greater stand diversity, especially as it relates to early-successional habitat. Encouraging aggressive forest management practices such as clear-cutting and shelter wood cutting in northern Connecticut may be beneficial for moose. Although regenerating forest may be of great importance, Telfer (1978) noted that high temperatures that reduce reproductive performance also might restrict expansion of moose populations into areas with otherwise adequate habitat.

Koitzsch (2002) found that in 2 areas of Vermont, HSI values were 0.34 and 0.64, however temperatures exceeded stress tolerance thresholds reported by Renecker and Hudson (1986, 1990) during 310 days of the year at both sites. HSI values for 6 counties in New Hampshire were similar to Vermont (0.35–0.63) (S. Williamson, Wildlife Management Institute, personal communication). Habitat suitability in Connecticut based on the HSI was low throughout the state, with few areas approaching the minimum

HSI values (0.34) recorded in Vermont or New Hampshire. Koitzsch (2002) was under the belief that heat stress is a limiting factor in Vermont and southern New England. In Connecticut, the number of days that temperatures exceeded heat tolerance thresholds for moose (203-299) was less than those reported by Koitzsch (2002) in Vermont, although comparisons could not be made during the same year. Schwab and Pitt (1991), and Dussault et al. (2004), found that during relatively warm periods, moose seek mature stands with coniferous trees to avoid exposure to intense solar radiation. Therefore ambient temperatures may not provide a true representation of heat exposure. Temperature information obtained from a moose with a GPS radio-collar in northern Connecticut indicated that under ideal conditions in Connecticut, where a moose occupied an area considered most suitable based on our landscape suitability analysis and moose behavior was taken into consideration, temperatures that induced heat stress were a concern. Although ambient temperature may not accurately reflect the effects of solar radiation from under the forest canopy where moose can escape direct solar exposure, it illustrates that moose in Connecticut likely were exposed to extended periods of heat stress annually.

Several methods can be used to validate HSI models, e.g. habitat use, animal density (Schamberger and O'Neil 1986, Allen et al. 1991), home range size (Allen et al. 1988), survival rate, reproductive success (Van Horne 1983, Allen et al. 1988, Van Horne and Wiens 1991), physiological condition (Schamberger and O'Neil 1986, Allen et al. 1988) and moose sightings (Hickey 2008). Similar to Hickey (2008) in New York, the results from the landscape suitability analysis for Connecticut were validated using density and distribution of moose sightings from the public and hunters. Density and distribution of public and hunter sightings were reflective of those areas with the highest landscape suitability (LS1-5). Public and hunter sightings were valuable tools for validating the landscape model because little information exists about moose in Connecticut.

The amount of timber harvesting in Connecticut is not likely to change drastically in the next several years. However, if trends in global warming continue, heat sensitive species like moose may be more prone to landscape limitations. Our HSI used FIDO data which is categorized at the county level. Four towns which were considered to have some of the best moose habitat (Howard Kilpatrick, personal communication) and had the greatest number of moose sightings, occurr in a county that had some of the highest human densities which inflated the HSI in that county, and reduced it in the adjacent county. The effects of spatial scales (county vs town) used for HSI models was limited by the data available. Therefore, management goals should not be based solely on model outputs.

With limited areas of regenerating forest and temperatures that induce heat stress in moose, landscape suitability for moose in Connecticut was low. The greatest concentration of moose would be expected along the Massachusetts border. Continued expansion into southern Connecticut may occur, but at low densities. Although several sightings of moose occurred outside areas identified as suitable moose habitat based on landscape suitability, most of those sightings were of transient animals that traveled south and were either struck by motor vehicles or were removed prior to becoming a serious public safety concern (H. Kilpatrick, personal communication). There is a low likelihood that moose would populate areas of lower Connecticut due to reduced landscape suitability and DEEP intervention due to public safety concerns (Ibid.). However, if existing moose densities increase, the frequency of animals dispersing into unsuitable areas of the state may increase.

MANAGEMENT IMPLICATIONS

Using landscape suitability to evaluate the potential existence of a species of concern such as moose is beneficial. Using a HSI model and easily obtained climatic data in states where little information exists about moose can provide agencies with insight about potential density and distribution of moose within their state. Incorporating these variables from this simple modeling exercise along with others may allow managers to make more informed decisions regarding whether moose hunting should occur or may aid in determining number of moose permits that should be issued for moose hunting.

Table 2.1. Habitat suitability index and potential moose densities by county, for Connecticut, USA, 2008.

County	% Urban	SIV10 % area small diameter	SIV11 % area conifer ≥ 20 yrs	SIV12 % area upland or deciduous ≥ 20yrs	SIV13 % area in wetlands	Habitat suitability index[1]	Estimated Moose/km^2
Fairfield	31.8	ND	ND	ND	ND	ND	0
Hartford	28.5	0.109	0.291	0.984	0.453	0.35	0.7
Litchfield	9.8	0.025	1.00	0.923	0.383	0.31	0.6
Middlesex	16.7	0.086	0.698	0.938	0.650	0.44	0.9
New Haven	31.3	0.010	0.014	1.00	0.540	0.09	0.2
New London	15.6	0.008	0.256	0.862	0.392	0.16	0.3
Tolland	13.2	0.063	0.999	1.00	0.200	0.34	0.7
Windham	11.2	0.086	0.440	1.00	0.282	0.32	0.6

ND = No data

SIV = Suitability index value

[1] Habitat suitability index values of 1 suggests the area has the potential to support 2 moose/km^2 (5/mi^2) (Allen et al. 1987).

Table 2.2. Landscape suitability (potential habitat, habitat suitability index, and temperature restrictions) for moose in Connecticut, USA, 2008.

Location	**Description**	**Potential Habitat Km^2**	**Moose/km^2 *temp (LS[1])**	**Total Potential Moose**
LS1[1]	Most suitable S/W[2] temp & least suitable HSI	224	0.6	134
LS2[1]	Suitable S/W[2] temp & suitable HSI	524	0.7*0.5	183
LS3[1]	Suitable S/W[2] temp & least suitable HSI	1,135	0.6*0.5	341
LS4[1]	Suitable S/W[2] temp & least suitable HSI	79	0.7*0.5	28
LS5[1]	Suitable S/W[2] temp & least suitable HSI	202	0.6*0.5	61
LS6[1]	Least suitable S/W[2] temps & suitable HSI	217	0.7*0.5*0.5	38
LS7[1]	Least suitable S/W[2] temps & suitable HSI	448	0.7*0.5*0.5	78
LS8[1]	Least suitable S/W[2] temps & suitable HSI	962	0.6*0.5*0.5	144
LS9[1]	Least suitable S/W[2] temps & suitable HSI	784	0.9*0.5*0.5	176
LS10[1]	Least suitable S/W[2] temp & least suitable HSI	768	0.6*0.5*0.5	115
LS11[1]	Least suitable S/W[2] temp & least suitable HSI	1,436	0.3*0.5*0.5	108

[1] Landscape suitability

[2] S = summer, W= winter

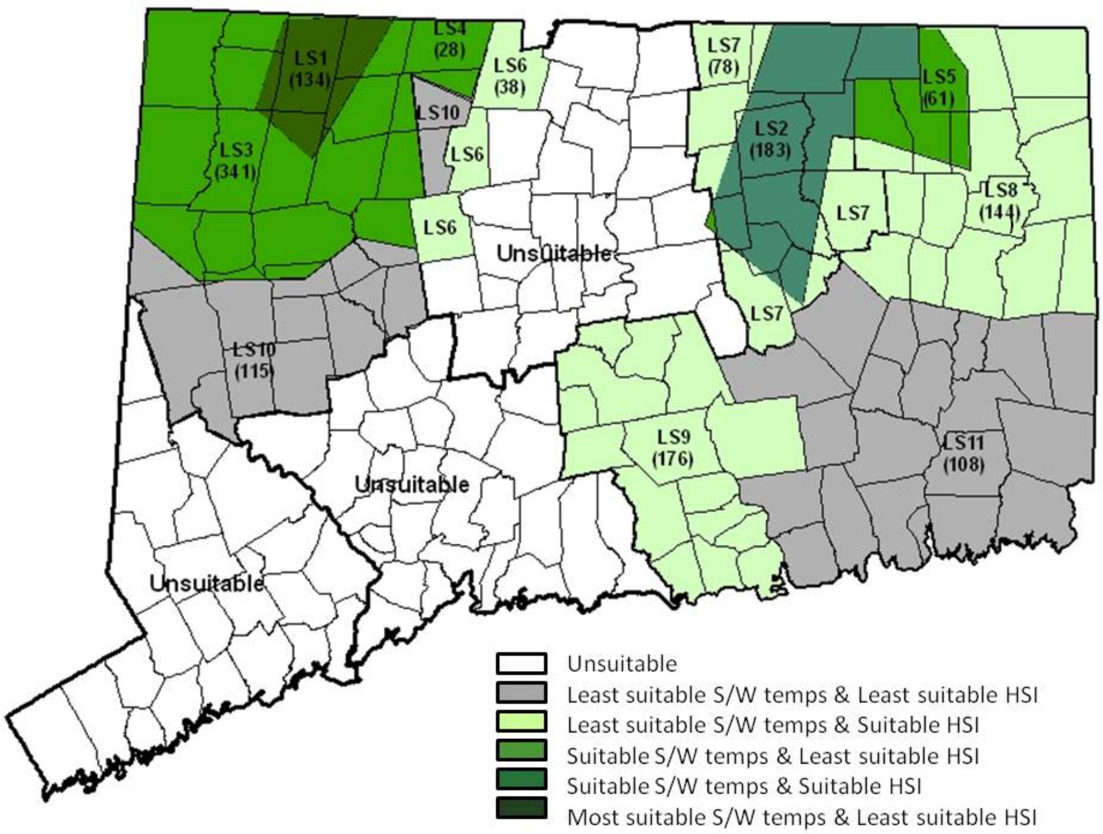
HSI = Habitat suitability index

Table 2.3. Elevation and days exceeding heat stress threshold levels (20°C summer and -5°C winter) for moose at 11 weather station locations in Connecticut, USA, 2008.

Locations	Elevation (meters)	Days exceeding threshold
Bridgeport	3	299
Burlington	152	252
Groton	12	288
Hampton	88	203
Windsor Locks	65	281
New Hartford	209	231
Norfolk	409	209
Staffordville	221	229
Storrs	198	238
West Thompson	110	239
Woodbury	285	253

Summer = 1 May – 30 September
Winter = 1 October – 30 April

Figure 2.1. Potential number and distribution of moose based on landscape suitability in Connecticut, USA, 2008.



S/W = Summer/Winter
HSI = Habitat suitability index

Figure 2.2. Density and distribution of moose sightings reported to the Department of Energy and Environmental Protection by the public in Connecticut, USA, 1992-2008.

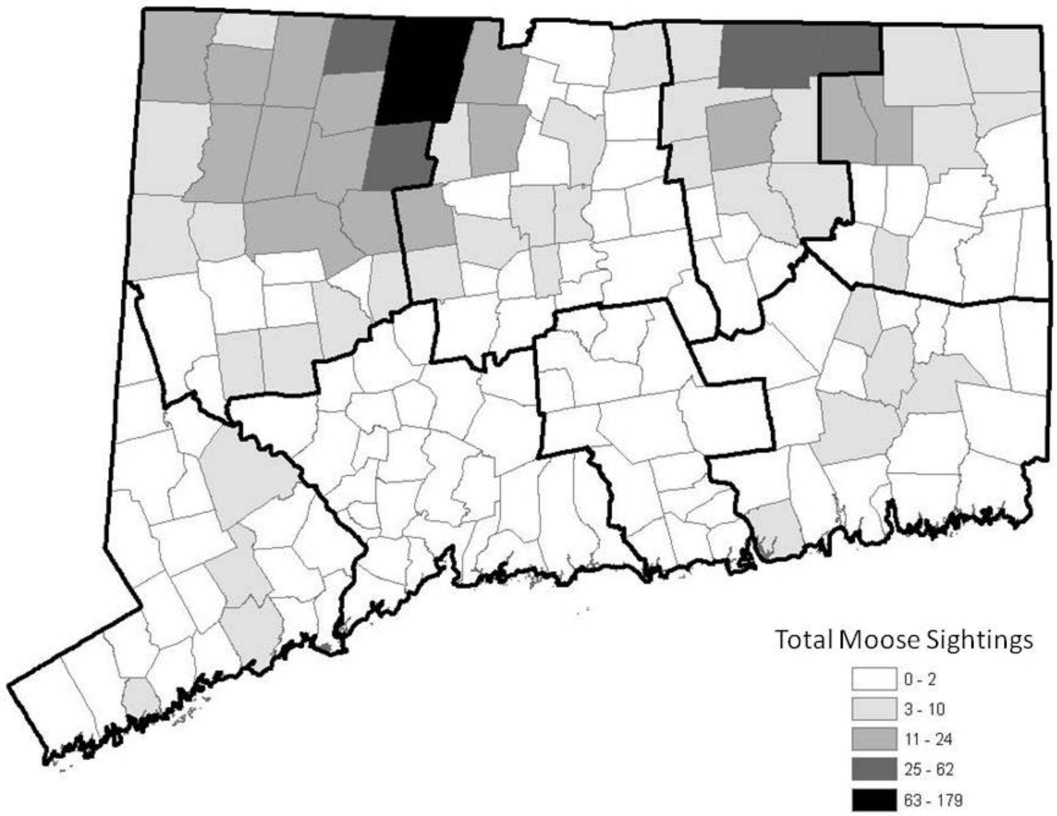


Figure 2.3. Distribution calf moose sightings reported to the Department of Energy and Environmental Protection in Connecticut, USA, 2000-2008.

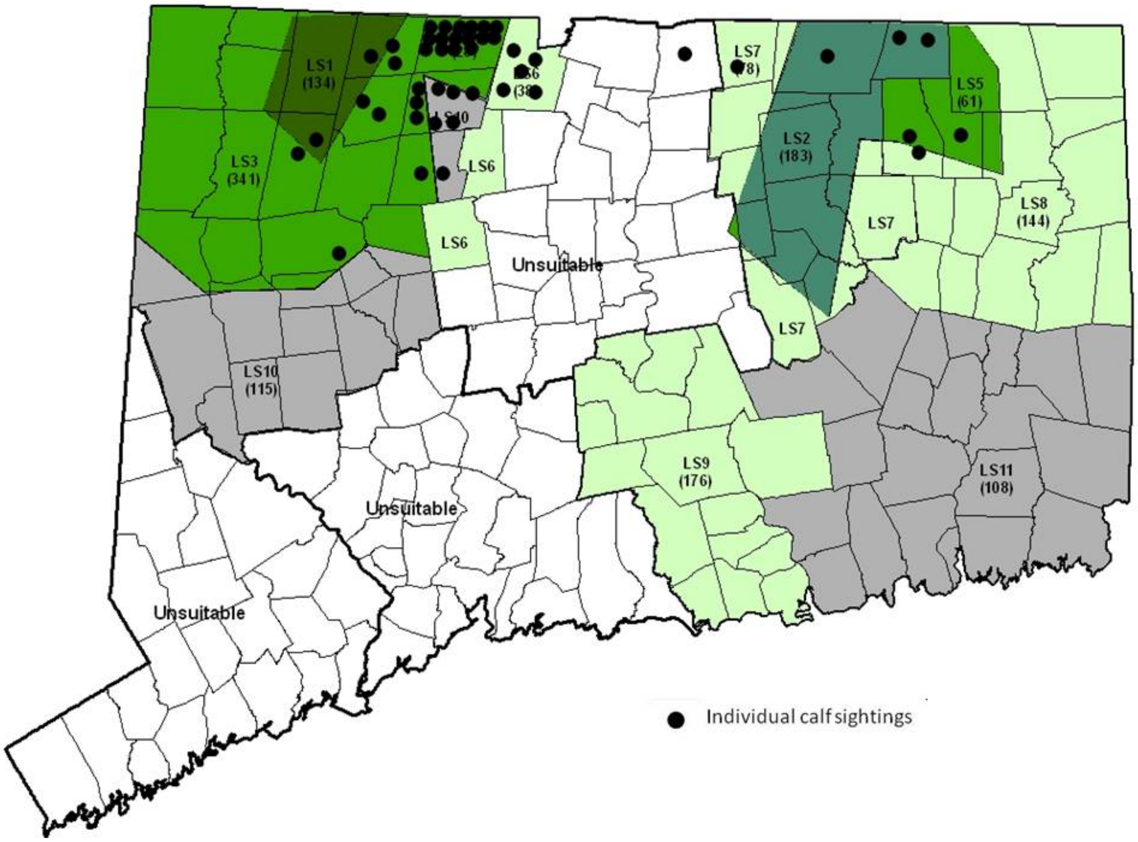
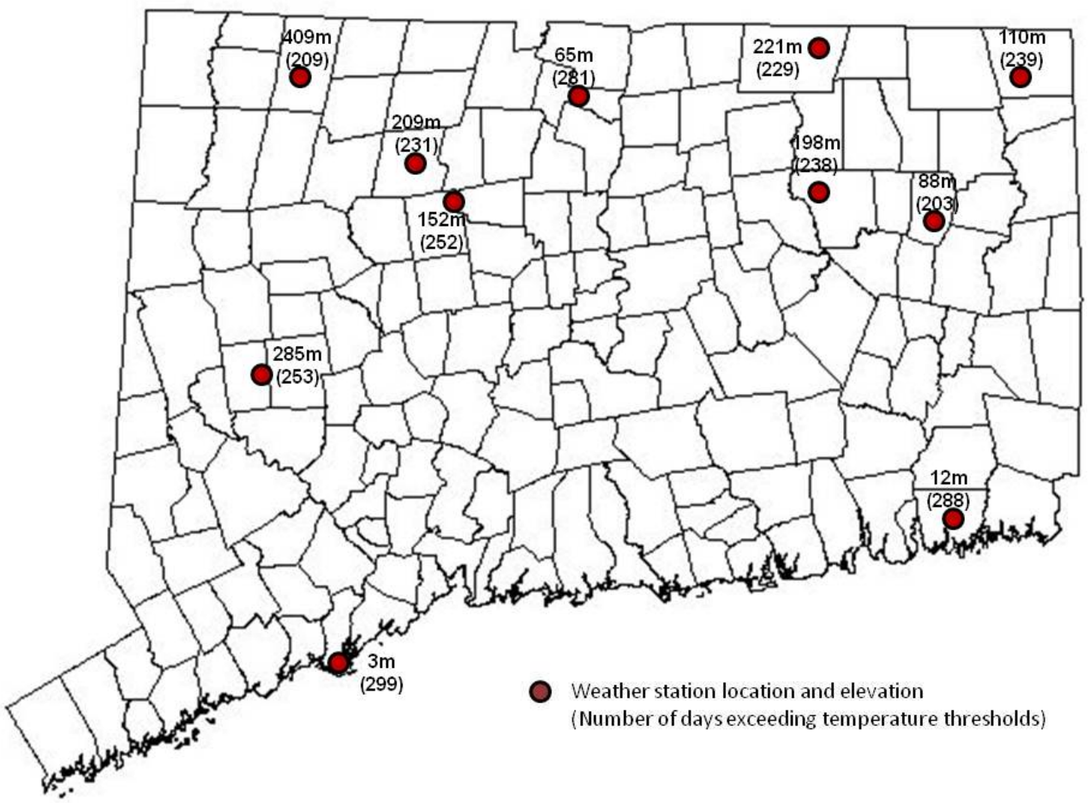


Figure 2.4. Weather station locations, elevation, and the number of days ambient air temperatures exceeded thresholds for moose during summer (20°C) and winter (-5°C) in Connecticut, USA, 2008.



Summer = 1 May – 30 September
Winter = 1 October – 30 April

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CHAPTER 3

MODELING A MOOSE POPULATION AT THE SOUTHERN EXTENT OF ITS RANGE: IMPLICATIONS FOR MANAGEMENT

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ABSTRACT: Moose population expansion in northern New England has resulted in the establishment and expansion of moose in southern New England. Expanding moose populations are attributed primarily to the abandonment of agriculture, changes in forest practices, lack of significant predators, and restrictive hunting laws, which allowed moose populations to increase in the late twentieth century. Our objectives were to document establishment of a resident moose population in Connecticut, monitor spatial and temporal distribution, and develop a minimum population estimate to predict future population growth under different management scenarios. In 1992, the Connecticut Wildlife Division began recording public sightings of moose and moose-vehicle accidents. In 1996, a question regarding hunter observations of moose during the fall hunting season was added to the annual deer hunter survey. In 2008, a moose population model was developed using public and hunter sightings of moose collected from 2005 to 2008. During this time, 232 public sightings of moose were reported in 55 towns and 176 hunter sightings of moose were reported in 33 towns. Based on public and hunter sightings, Connecticut's moose population was conservatively estimated at 73 in 2008. The population could be expected to exceed 257 moose in 20 years, if no harvest management strategy were applied. If left unmanaged, more effort may be required to manage the population and increased human conflicts could be expected.

KEY WORDS: STELLA®, *Alces alces americana*, modeling, moose, sightings

Alces 00(0): 000–000

Historical distributions of moose (*Alces* spp) in North America have been associated with glacial epochs and presence of boreal forests (Franzmann 1980). With the retreat of glaciers and expansion of boreal forests, moose populations expanded northward (Ibid.) into areas with few humans. Moose expansion into previously unpopulated areas was documented in Labrador (Chubbs and Schaefer 1997), Quebec (Brassard et al. 1974), Newfoundland (Fryxell et al. 1988), and northern Alaska (Coady 1980). A moose population in Newfoundland expanded at a rate of 11 km per year (Pimlott 1953). Similarly, a population in Labrador expanded at a rate of 8 km per year at which time the population increased 49-56% over an 8-year period (Chubbs and Schaefer 1997). Distribution of moose in the north has been limited by absence of woody plants on the tundra, in western mountain ranges by excessive snow depth and lack of woody plants, on prairies and arid valleys of the south and west by the absence of shade, water and suitable food, and in the southeast by neurological disease (Kelsall and Telfer 1974, Renecker and Hudson 1986, Karns 2007). Other factors that affect moose populations include severe winters, predation, regulated hunting, poaching, competition with deer (*Odocoileus* spp.), and accidental death (Kelsall and Telfer 1974, Bertram and Vivion 2002).

Eastern moose (*Alces alces americana*) in northern New England were abundant in the 1600s. However, by the 1800s, moose numbers had declined considerably due to habitat loss and unregulated hunting (Alexander 1993, Vashon 2008, Snyder and Rines 2010). Moose existed in Massachusetts and Connecticut (Trumbull 1797, DeForest 1964) but were extirpated in the 1800s (Goodwin 1935). Changes in land use, lack of significant predators, and restrictive hunting laws allowed for moose populations in northern New England to increase through the late 1900s (Alexander 1993, Vecellio 1993, Kilpatrick et al. 2003, Vashon 2008). Hunting seasons were established in Maine (1980), New Hampshire, (1987), and Vermont (1993) to manage increasing moose populations that now exceed 40,000 moose (Alexander et al. 1998, Vashon 2008, Snyder and Rines 2010). Unlike past northerly expansions, increasing moose populations in northern New England have led to a southerly expansion into Massachusetts (DeStefano and Wattles 2010) and Connecticut (Kilpatrick 2003).

Moose occasionally appeared in Connecticut throughout the early-to-mid 1900s (Connecticut Wildlife 2000); however, no evidence has been found that a resident breeding population existed prior to 2000 (Kilpatrick et al. 2003). In 2000, based on public sightings a resident breeding moose population naturally became reestablished and was expanding in size and distribution (Ibid.).

Several methods (i.e. ground and aerial surveys, hunter sightings and harvest) exist to estimate moose populations with varying degrees of sophistication, accuracy, and cost (Davis and Winsted 1980, Timmerman and Buss 2007). Counting moose on winter range from aircraft has been the most widely used method for estimating moose populations in North America (Gasaway et al. 1986, Timmermann 1993). However, several states in the northeast have used sighting rates of moose by hunters for estimating moose populations (K. Rines, New Hampshire Fish and Game Department, C. Alexander, Vermont Fish and Wildlife Department, L. Kantar, Maine Department of Inland Fisheries and Wildlife, personal communication). Few data on moose is available and no current population estimate exists for moose in Connecticut, thus the expectation of future population expansion in the state is unclear. Our objectives were to develop a minimum population estimate based on public and hunter sightings of moose, predict future population growth under different management scenarios and assess the effort required to stabilize the moose population at its current level, and in 5, 10, and 15 years.

STUDY AREA

The study area was the state of Connecticut (12,548.5 km^2) which was the fourth most densely populated state (3,500,000 people, (278 people/ km^2)) in the United States (Connecticut Economic Resource Center 2006, 2010). Located in southern New England, Connecticut is bounded on the south by Long Island Sound, and by the states of Rhode Island to the east, Massachusetts to the north, and New York to the west. Connecticut was primarily forested (55.6%), 20% developed or barren, 16.7% turf, grass or agricultural field, 4.4% wetlands (non-forested, forested, and tidal), and 3.2% water (Hochholzer 2010).

METHODS

Public and hunter sightings

In 1992, the Department of Energy and Environmental Protection (DEEP) began documenting all credible public moose sightings and moose-vehicle accidents (MVA's). The DEEP received unsolicited sightings from the public by mail, telephone, and in person. Moose-vehicle accident reports were received from Connecticut Conservation Law Enforcement officers and directly from the general public (H. Kilpatrick, Connecticut Department of Energy and Environmental Protection, Wildlife Division, personal communication). Sightings were evaluated by a biologist for credibility (Ibid.).

A question was added to the annual deer hunter questionnaire in 1999 asking hunters to report all sightings of moose during the deer hunting season. A conservative population model was developed using all reported credible public and hunter sightings of moose from 2005-2008, excluding those associated with a moose killed in a moose-vehicle accident. All moose sightings reported by the public and by deer hunters from 1 January 2005 to 31 December 2008 were obtained from the Connecticut Department of Energy and Environmental Protection, Wildlife Division, and were plotted on a digital orthoquad map in ArcGIS 9.2 (ESRI, Redland, CA). If sightings included detailed locations they were geo-referenced. Sightings that could not be geo-referenced were placed in the center of the town where the sighting occurred. Each moose location was color-coded to represent an animal's age and sex class, (bull, cow, calf, unknown), and year observed (Figure 1). In 2005, individual moose observations were counted. A circle with a 2.86-km radius was placed around each moose location to represent a mean home range size of 25.9 km^2 (Liptich and Gilbert 1989,Cederlund and Sand 1994) (Figure 3.1).

If >1 moose sighting of the same sex was observed within the 25.9 km^2 home range over the 4-year period it was considered as 1 animal to produce a minimum population estimate. If the home range of a cow with 1 calf overlapped with the home range of a cow with 2 calves during the same year, they were counted as different individuals. Animals whose sex was unknown were not counted unless they occurred outside the area of an animal whose sex was known. If sightings with an unknown sex occurred outside that area, an even sex ratio of 50:50 was used to place unknown animals into a sex and class for modeling population growth. Total individual sightings were then counted to generate an initial population.

Model simulations

Program STELLA® (High Performance Systems Inc., Lebanon N.H.) was used to model the current population dynamics of Connecticut's moose population. We developed an empirical model of the moose population using site-specific data and data from other studies. A recruitment rate of 0.31 calves per cow ≥ 1 year old (based on public sightings) was used to generate growth rate of the moose population. Calf sex ratio was assumed to be 50:50 (Schwartz and Hundertmark 1993). Adult mortality in the model varied randomly between 4-8% based on studies where few natural predators existed (Mytton and Keith 1981, Gasaway et al. 1983, Fryxell et al.1988, Gasaway et al. 1992). We used the model to predict expected growth of the moose population over a 20-year period in the absence of hunting. The model was run 10 times to generate mean population estimates and confidence limits. We added harvest management strategies (establishing a hunting season immediately, or waiting 5 and 10 years) to the model to estimate relative impact on population growth. Using the various management strategies, a constant mortality rate was used for each strategy and applied so that at the end of 5 years of management, the population would be the same as the starting population (2008). We focused on modeling the female segment of the population because manipulating number of female moose would have the greatest impact on simulated moose population growth. A harvest sex ratio of 1 cow to 2.5 bulls was used based on observed harvest ratios in Vermont where either-sex tags were issued (Alexander et al. 1998) to extrapolate total annual moose harvest required to stabilize population growth at the 2008 level (~ 36 females) and in 5 and 10 years if either sex tags were issued. Based on our analysis using the Shapiro-Wilk statistic ($P > 0.05$) for normality, we evaluated the number of moose required to stabilize population growth during the first five years of hunting if it began now, and in 5, and 10 years using Analysis of Variance ($P < 0.05$) in SYSTAT 12.0 (Systat Software, Inc., San Jose, California).

RESULTS

Public and hunter sightings

From 2005 to 2008, 232 public sightings of moose ($\bar{x}$ = 60.3 moose sightings/year, SD = 14.2) were reported in 55 towns (Figure 3.2, 3.3). From 2005 to 2008, 176 hunter sightings of moose ($\bar{x}$ = 44.0 moose sightings/year, SD = 15.8) were reported in 33 towns (Figure 3.2, 3.4). An initial (2008) minimum population estimate of 73 moose (32 adult cows, 32 adult bulls, 9 calves) was derived from public and hunter sightings from 2005 to 2008.

Model simulations

With no management, the moose population was estimated to increase 24% in 5 years ($\bar{x}$ = 90.9±0.77, SD = 1.1), 70% in 10 years ($\bar{x}$ = 124.4±1.7, SD = 2.3), 140% in

15 years ($\bar{x}$ = 176.4±2.2, SD = 4.9), and 253% in 20 years ($\bar{x}$ = 257.3±5.3, SD = 7.4) (Table 3.1).

If hunting was initiated in 2008, 2.68 (SD = 0.01) cows or 9 moose would need to be harvested annually (8.5% hunting mortality rate as constant) to achieve population stabilization over the next 5 years. If hunting were delayed 5 years (2013), 6.2 (SD = 0.66) cows or 16 moose would need to be harvested annually (17% hunting mortality rate as constant) to achieve population stability at the 2008 population level over the next 5 years. If hunting were delayed 10 years (2018), 11.1 (SD = 2.5) cows or 28 moose would need to be harvest annually (26% hunting mortality rate as constant) to achieve population stability at the 2008 population level over the next 5 years. Mean number of female moose required to be harvested annually during the initial 5-year period following the establishment of a hunting season compared to waiting 5 or 10 years, increased significantly ($F_{2,147} = 413.3$, $P < 0.001$).

DISCUSSION

Based on our analysis of public moose sightings from the mid-to-late 2000s, the size of the population and distribution of moose appears to have expanded gradually through western Connecticut and has become more limited in eastern Connecticut in the late 2000s (Figure 3.3), compared to distribution in early 2000 (Kilpatrick et al. 2003, Figure 3.5). A plausible explanation for the shift in public sightings from east to west likely is an artifact of the movements of individual moose dispersing during the spring period of which nearly all were struck and killed on the highway or relocated back to northern Connecticut (Kilpatrick et al. 2003, A. LaBonte, unpublished data). Looking at only cow/calf sightings and towns with > 5 moose sightings, our findings are similar to

Kilpatrick et al. (2003) (Figure 3.5), indicating little expansion has occurred. Moose distribution based on hunter sightings has been more limited in southern Connecticut in the late 2000s (Figure 3.4) compared to early 2000s (Kilpatrick et al. 2003, Figure 3.6). Hunter sightings of moose may provide a more realistic representation of moose distribution than do public reports, since hunter sightings occur from September-December. Using public sightings reported during the spring dispersal period (May-June), when moose have been documented traveling as many as 8-16 km per day, often through urbanized areas (H. Kilpatrick, personal communication), may overestimate populations. If public sightings were used for modeling, it may be valuable to eliminate public sightings that occur during the spring dispersal period.

LaBonte and Kilpatrick (2006), using similar methods, estimated the moose population in Connecticut at 64 moose in 2004. Our population estimate was approximately 73 moose in 2008 with the potential to grow exponentially in the next 20 years. Using 2004 as a comparison, the current rate of growth for moose expanding at the southern extent of their range (3% per year) is much less than growth rates (7% per year) documented at times when moose were expanding along the northern extent of their range (Chubbs and Schaefer 1997). Mortality rates found at the southern extent of moose range may be greater than those found in other parts of the country where fewer predators exist (Mytton and Keith 1981, Gasaway et al. 1983, Fryxell et al.1988, Gasaway et al. 1992). Although Connecticut lacks the variety of large predators found throughout most moose range, other mortality factors such as those associated with climate (Renecker and Hudson 1974, Lenarz et al. 2009) and disease (Murray et al. 2006) may limit moose population expansion as previously documented (Kelsall and Telfer 1974, Renecker and Hudson 1986) and may be highly influential on our model.

We found that nearly a third of Connecticut towns have documented moose over the past 4 years. Although most of Connecticut's moose population appears to reside along the Massachusetts border (based on reported sightings), some moose have dispersed into highly developed areas in southern Connecticut. Most sightings that occur in lower Connecticut are from moose dispersing during the spring (H. Kilpatrick, personal communication). A dispersing moose often results in a moose being struck by a motor vehicle, relocated within the state, or euthanized (Ibid.). A moose population poses special problems, especially in southern Connecticut, as the area is highly developed, fragmented by roads, and has limited suitable habitat (Ibid.). Although unlikely, based on the estimated rate of growth when compared to LaBonte and Kilpatrick (2006), an unmanaged moose population in CT, based solely on our empirical model could grow at an exponential rate and create a significant public safety concern. A model that incorporated habitat and temperature indicated that landscape suitability in Connecticut is limited, but may support upwards of 1,400 moose (LaBonte, unpublished data).

Regulated hunting has allowed for use of a natural resource such as moose in other states and is shown to be an efficient way to manage moose populations throughout their range (Timmerman and Buss 2007). If an either-sex hunting season were to have been established in Connecticut in 2008, few animals (~9) would have to be harvested annually to stabilize population growth. If no management occurred for another 5 to 10 years, approximately 16 to 28 animals would have to be harvested annually the first 5 years before stabilizing the moose population. If the moose population expands as predicted by our model, it would be important to establish a limited moose hunting season sooner rather than later to minimize potential public safety hazards (McDonald 2004). As the moose population has continued to expand in southern New England, the number of moose-vehicle accidents in Massachusetts and Connecticut (where no hunting seasons exist), has increased from 74 in the 1990s to 258 in 2000s (S. Christensen, Massachusetts Division of Fisheries, Wildlife, and Law Enforcement, H. Kilpatrick, personal communication).

Although model simulations are simplistic representations of complex systems and cannot account for all interactions in the real world, they can be meaningful for assessing relative population growth under different management scenarios (Kilpatrick et al. 2004). Based on our model, Connecticut may have the potential to experience the same rapid growth and expansion of the moose population as experienced in Massachusetts (DeStefano and Wattles 2010).

MANAGEMENT IMPLICATIONS

Using public and hunter sightings can be an inexpensive, yet useful tool for developing and validating models to predict population growth when little information exists about a species. However, as a population increases, the value of public moose sightings may decline over time. It would be useful to evaluate the population using the same methodology on a bi-annual basis to better predict population growth rates based on public and hunter sightings. It also may be valuable to utilize only sightings outside the spring dispersal period i.e. autumn/winter or only hunter sightings. Capturing and marking animals to better evaluate population growth, home range size, habitat use, and causes of mortality in Connecticut, would be beneficial. If the population continues to grow at the predicted rate, we would also recommend actively managing the moose population through hunting to maintain it at low levels to minimize human-moose conflicts.

Table 3.1. Initial and projected moose population based on a population model using program Stella and sightings reported to the Connecticut Department of Energy and Environmental Protection in Connecticut, USA, 2005-2008.

	Initial Pop	Projected Population							
	(2008)	5 Years		10 Years		15 Years		20 Years	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cows	32	33.0	0.63	40.7	0.96	55.4	1.7	80.6	3.3
Bulls	32	45.9	0.41	66.6	0.83	96.2	1.6	140.9	3.2
Calves	9	13.2	0.04	19.2	0.13	27.8	0.2	40.4	0.45
Total	73	90.9	1.1	124.4	2.3	176.4	3.0	257.3	7.4

Figure 3.1. Example of data used to generate minimum moose population estimate based on sightings reported to the Department of Energy and Environmental Protection by the public and hunters in Connecticut, USA 2005-2008.

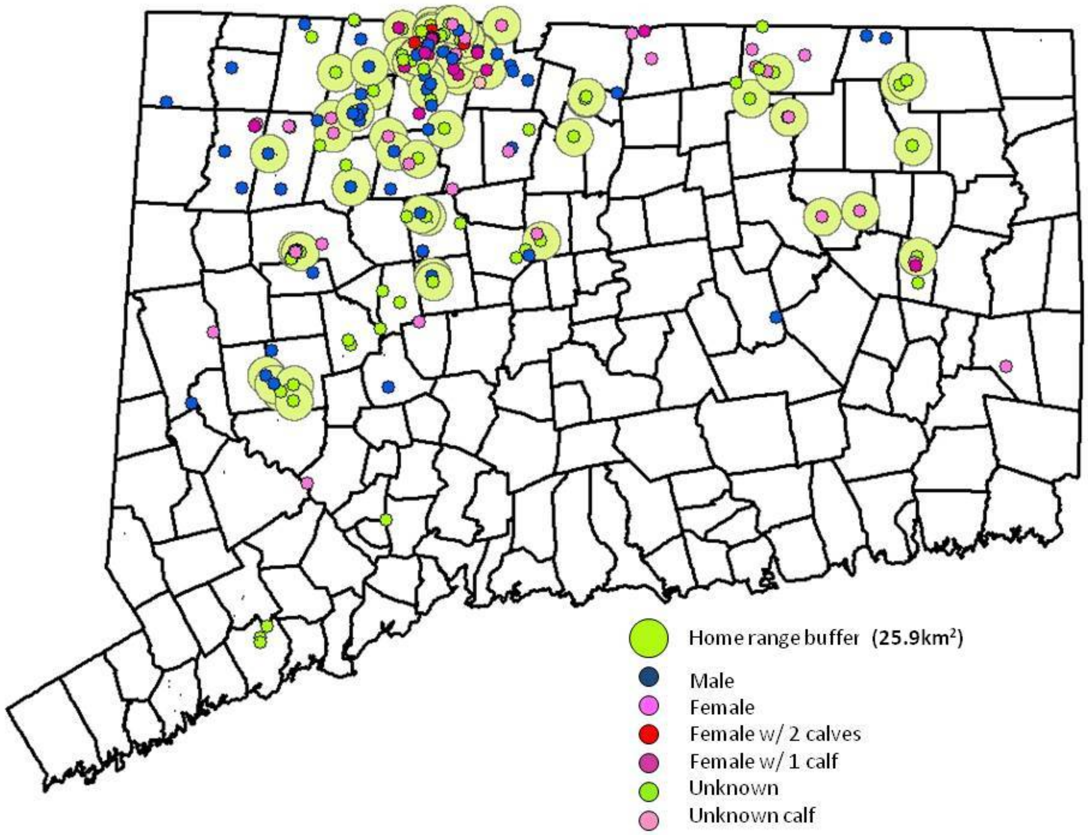


Figure 3.2. Moose sightings reported to the Connecticut Department of Energy and Environmental Protection by the public and hunters in Connecticut, USA, 2005–2008.

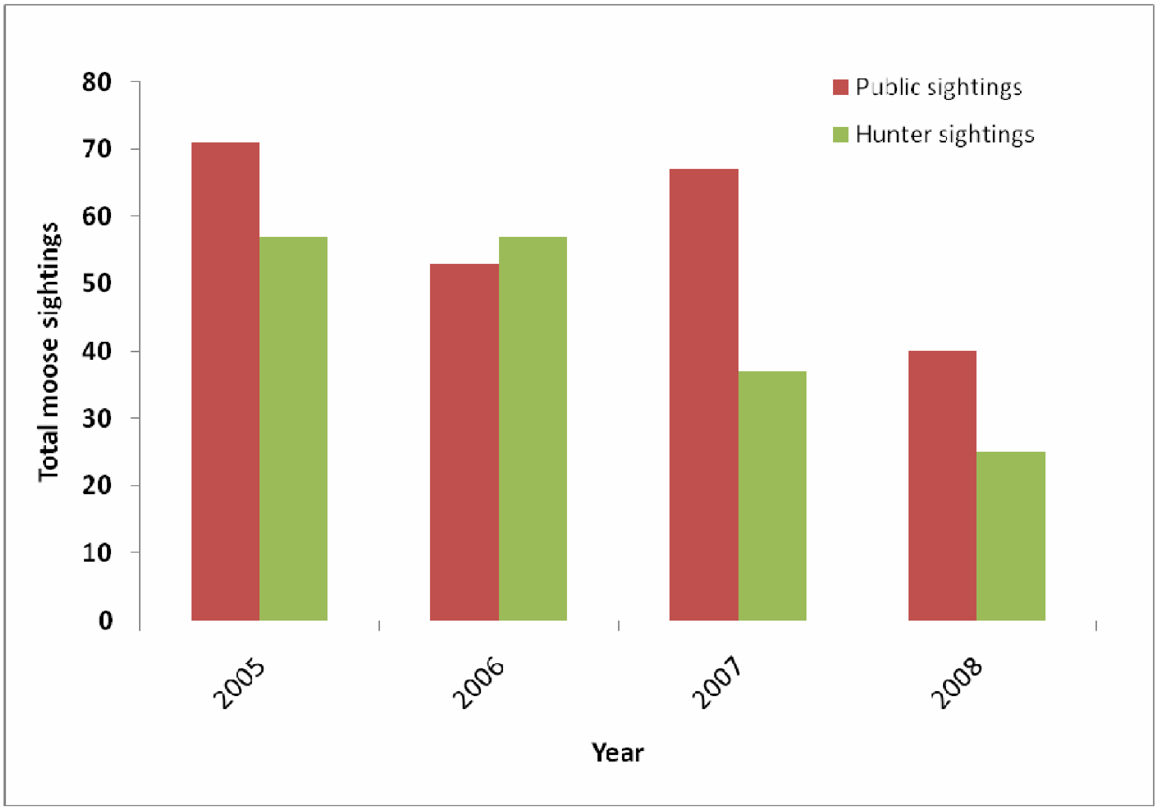


Figure 3.3. Distribution of moose sightings reported to the Department of Energy and Environmental Protection by the public in Connecticut, USA, 2005–2008.

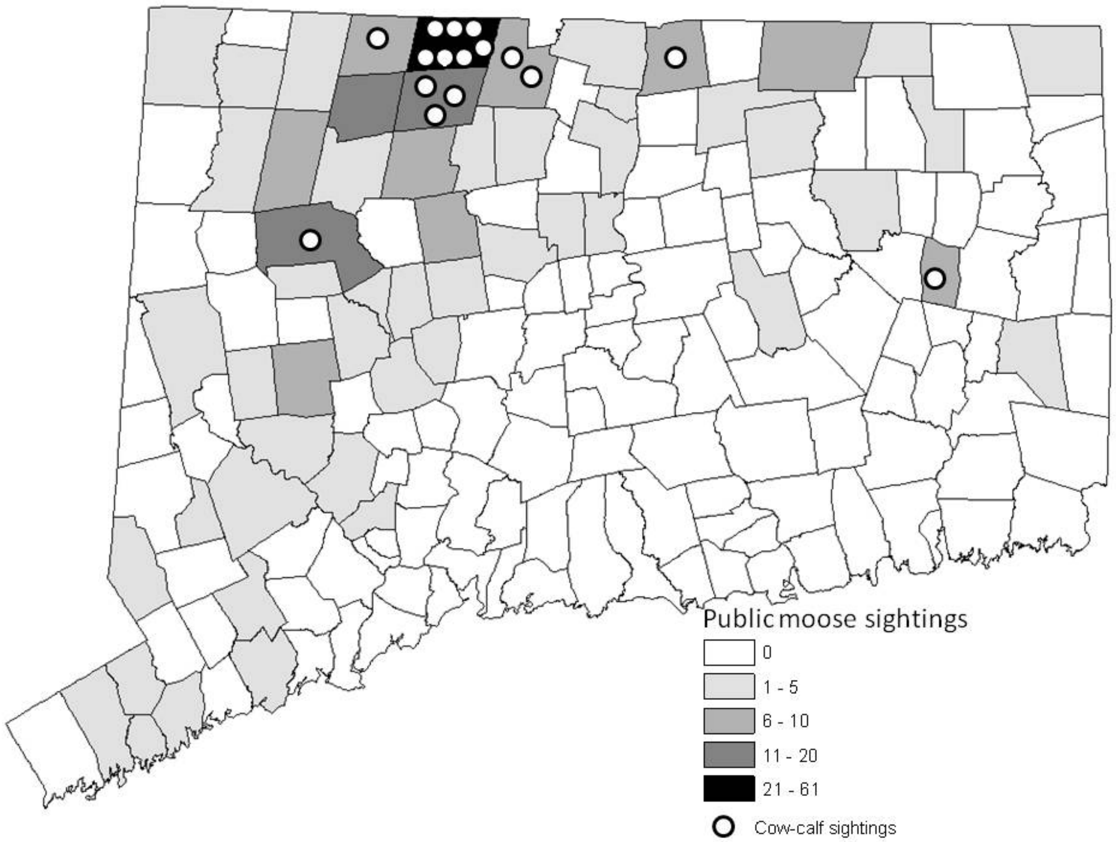


Figure 3.4. Distribution of moose sightings reported to the Department of Energy and Environmental Protection by hunters in Connecticut, USA, 2005–2008.

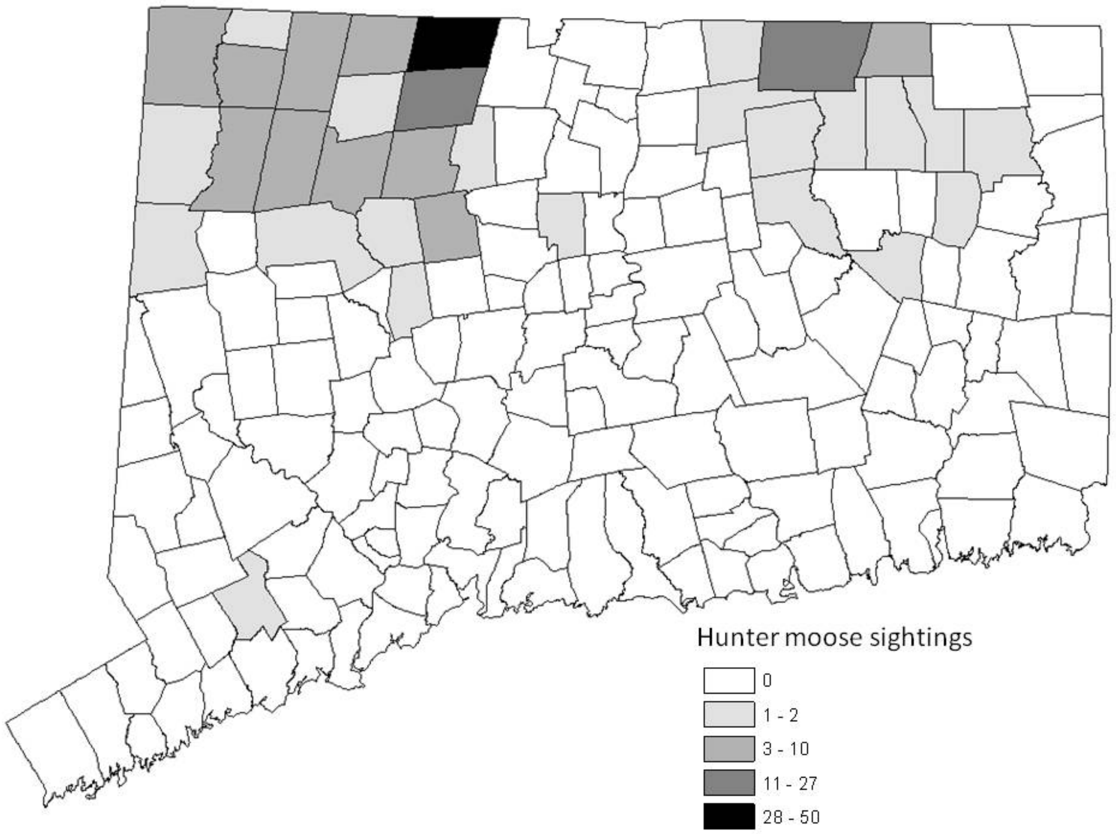


Figure 3.5. Distribution of moose sightings reported to the Department of Energy and Environmental Protection by the public in Connecticut, USA, 1992-2002 (Kilpatrick et al. 2003).

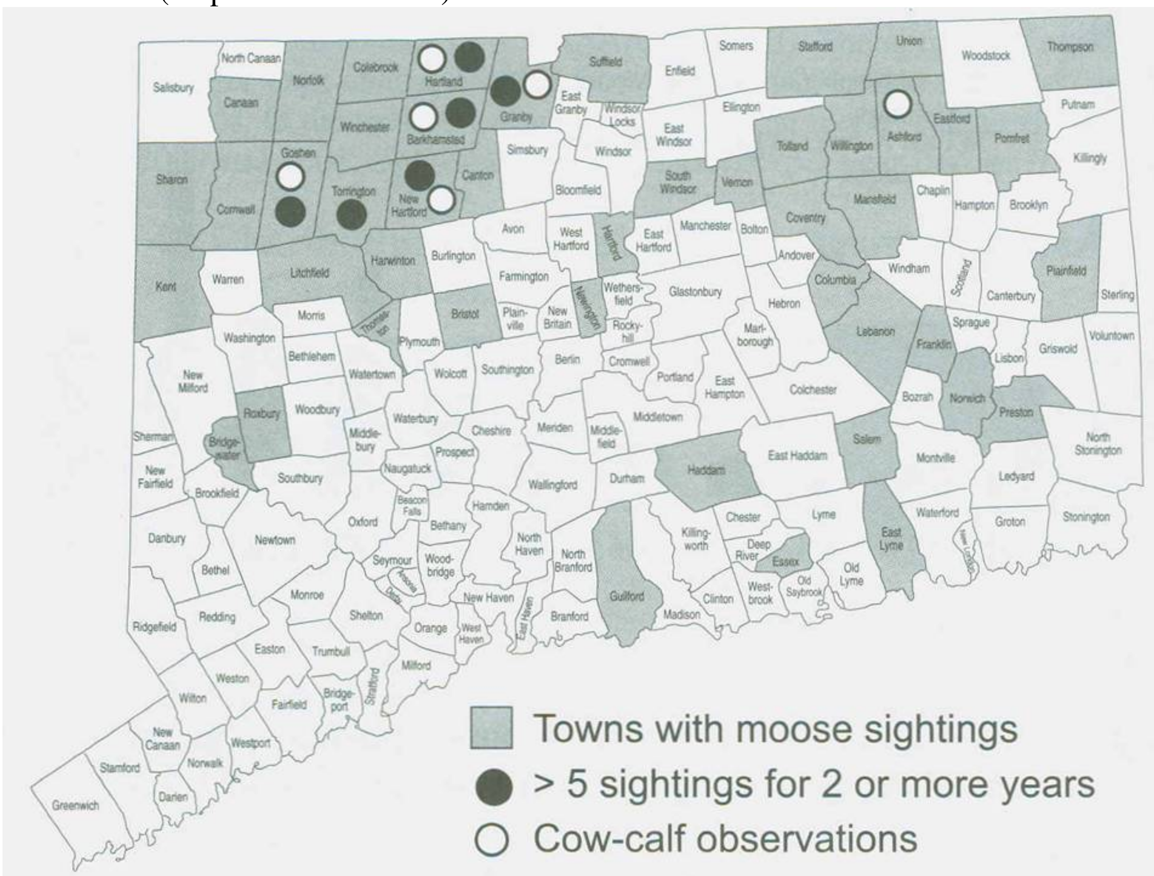
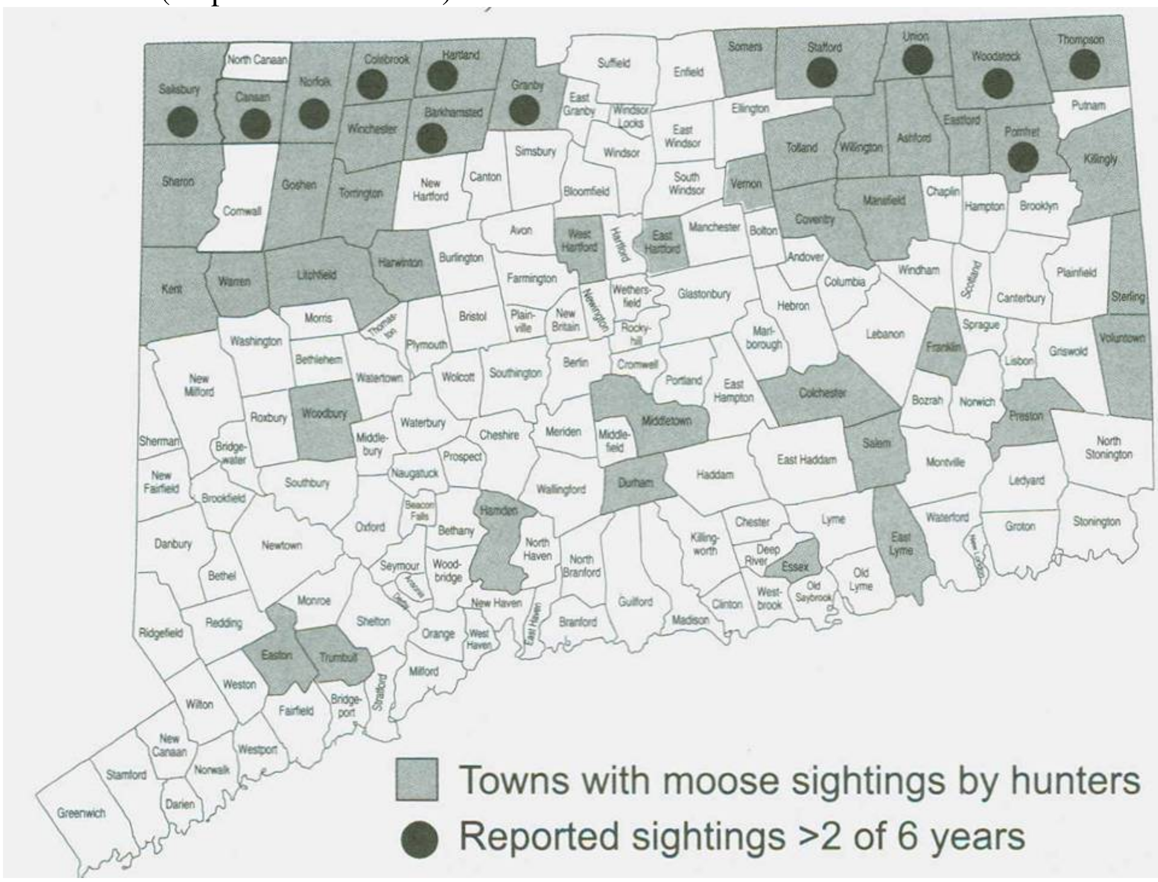


Figure 3.6. Distribution of moose sightings reported to the Department of Energy and Environmental Protection by hunters in Connecticut, USA, 1996-2001 (Kilpatrick et al. 2003).



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CHAPTER 4

OPINIONS ABOUT MOOSE AND MOOSE MANAGEMENT AT THE SOUTHERN EXTENT OF MOOSE RANGE

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ABSTRACT: Eastern Moose (*Alces alces americana*) populations have expanded throughout southern New England over the past 40 years. Increasing moose populations present new challenges for wildlife managers who must balance beneficial and adverse aspects of expanding moose populations. It is important that managers understand stakeholder attitudes and how this information should be incorporated into implementing outreach and management programs that consider human preferences and wildlife population dynamics. Our objectives were to assess public and hunter perceptions about status, management, and concerns associated with an expanding moose population. We also assessed differences in landowner responses at the landscape level. The majority of landowners and hunters believed < 100 moose existed in Connecticut, most thought the population was increasing, but believed the population was too low, as few had ever observed a moose in Connecticut or been involved in a moose-vehicle accident. Support for hunting by landowners initially was low, but increased as potential concerns,

especially related to moose-vehicle accidents increased, while support by hunters was high. No differences existed at the landscape level for landowners except for personal experiences with moose. We expect a reduction in the public's capacity for moose given further conflicts. The need for increased public education, increased public understanding of the role of lethal management to protect humans, and being proactive rather than reactive will be critical for successful moose management in Connecticut. Education efforts should be undertaken to increase public and hunter awareness about moose in Connecticut.

KEY WORDS: *Alces alces americana*, moose, residents, hunters, opinions, management

Alces 00(0): 000–000

Eastern Moose (*Alces alces americana*) populations have increased throughout northern New England over the past 40 years (Alexander 1993, Vecellio et al. 1993, Vashon 2008, DeStefano and Wattles 2010, Snyder and Rines 2010). Increasing moose populations present new challenges for wildlife managers who must balance beneficial and adverse aspects of expanding moose populations. Moose provide some intrinsic economic value to both consumptive and non-consumptive users (Schwartz and Bartley 1991). Watching and hunting moose are two major revenue generators (Wolfe 1987, Timmermann and Rodgers 2005). However, populations that reach levels where recreational opportunities exist can also produce adverse consequences in the form of moose-vehicle accidents (MVA) and ecological damage (Timmermann and Rodgers 2005). Increasing moose populations have the potential to generate increased human conflict due to their size, speed, nocturnal behavior, and seasonal mobility (Mirick 1999).

Assessing attitudes of various stakeholder groups toward a wildlife species can be useful for understanding stakeholder support and opposition towards potential management decisions (Bath and Enck 2003). Incorporating stakeholder attitudes into outreach and management programs is important (Teel et al. 2002).

Natural resource agencies increasingly have emphasized stakeholder participation in wildlife management decision making (Lauber and Knuth 1997) and management of interactions between people and wildlife (Ericsson 2003). Incorporating stakeholder opinions into the decision-making process should improve public acceptance, improve implementation of management plans (Flanigan 1987, Hartig and Thomas 1988, Pinkerton 1991, Landre and Knuth 1993), strengthen relationships between agencies and the public (Landre and Knuth 1993), and reduce conflict (Erickson 1979, Twight and Patternson 1979, Nelkin 1984, Blahna and Yonts-Shepherd 1989).

Several researchers have assessed human dimensions issues related to wildlife and natural resources (Teel et al. 2002, Lee and Miller 2003, Chavez et al. 2005, Kilpatrick et al. 2007). However, human dimensions research related to moose in North America is limited (Wolfe 1987). Ericsson (2003) evaluated articles in *Alces* from 1974-2001 and found a gap between a growing interest to study human dimensions as it pertains to moose and the actual effort made to understand the human dimensions component in moose research. The majority of human dimensions articles published between 1974 and 2001 pertain to hunting of moose or collisions with moose, while few assessed public values or attitudes towards moose (Ericsson 2003).

In the northeast, Alexander (1993), Donnelly and Vaske (1995), and Lauber and Knuth (1997, 1999) evaluated public opinions about moose and proposed moose management proposals. However, no information exists about public perceptions about moose or potential management decisions along the southern extent of their range. As problems associated with moose populations become more common, the need to develop management strategies that are both effective and acceptable to the public becomes increasingly important. The potential for moose populations to continue expanding in southern New England and the long-term impacts moose may have on residents is unclear.

Understanding public and hunter opinions about moose and moose management is essential for the development of a moose management plan that will aid in addressing public, hunter, and agency concerns about expanding moose populations. Our objectives were to assess public and hunter perceptions about status, management, and concerns associated with an expanding moose population. We also assessed differences in landowner responses at the landscape level.

STUDY AREA

The study area was the state of Connecticut (12,548 km^2) which was the fourth most densely populated area (3,500,000 people, (278 people/ km^2)) in the United States (Connecticut Economic Resource Center 2006, 2010). Located in southern New England, Connecticut is bounded on the south by Long Island Sound, and by the states of Rhode Island to the east, Massachusetts to the north, and New York to the west. Connecticut was primarily forested (55.6%), 20% developed or barren, 16.7% turf, grass or agricultural field, 4.4% wetlands (non-forested, forested, and tidal), and 3.2% water (Hochholzer 2010).

Historic accounts suggest that moose existed in Connecticut prior to the eighteenth century (Trumbull 1797, DeForest 1964). However, Goodwin (1935) noted that at the beginning of the eighteenth century there were no records of moose in Connecticut. According to the Connecticut State Archaeologist, no archaeological deposits of moose exist (N. Bellantoni, Connecticut State Archeologist, personal communication) indicating that moose, if ever a native, likely existed in low numbers.

Between 1916 and 1956 reports of transient moose in Connecticut were made on a few occasions (Connecticut Wildlife 2000). On 18 September 1956, the Board of Fisheries and Game, now the Department of Energy and Environmental Protection (DEEP), passed an emergency regulation that gave full protection to moose found in Connecticut. Up till the early 1990s sporadic reports of transient moose were reported (Kilpatrick et al. 2003). In 1992, the DEEP began documenting all credible moose sightings reported by the public and moose-vehicle accidents. A question was added to the annual deer hunter questionnaire in 1996 asking hunters if they had observed a moose during the hunting season.

In 1998, the Connecticut DEEP, Wildlife Division adopted a directive (DEEP2431-D1) that outlined procedures for responding to problem moose situations in Connecticut that included hazing, capture and relocation, and euthanization. Since 2000, reports of cows with calves, confirmed the establishment of a residential moose population (Kilpatrick et al. 2003) and public sightings suggested Connecticut's moose population was expanding in size and distribution.

An empirical model conservatively estimated that at least 64 moose in 2004 (LaBonte and Kilpatrick 2006) and at least 73 moose (A. LaBonte, unpublished data) existed in CT at the time of this survey.

Based on distribution of moose sightings from the public (Kilpatrick et al. 2003, Figure 4.1) and hunters (LaBonte et al. 2008, Figure 4.2), northern Connecticut was selected as the study area for the landowner survey. Based on geographic features and an assessment of human population densities, towns in northern Connecticut were delineated into 3 groups for the landowner survey (Figure 4.3) and were used for landscape level comparisons. Towns were grouped as "eastern" (n = 16), "central" (n = 13), and "western" (n = 20) (Table 4.1, Figure 4.3).

METHODS

Landowner Survey

A database containing the names and addresses of landowners from 49 towns in the northern third of Connecticut was obtained from municipal town offices. We set a sampling rule to include private landowners and removed all identifiable outliers (Limited liability company's, Corporation's, Companies, Schools, Churches, Trustees, Towns, etc.). We deleted duplicate landowner records (due to ownership of multiple tracts) to compile a list of landowners with an equal likelihood of being randomly selected and so each landowner would receive only 1 survey.

We calculated minimum sample sizes required for each area based on a stratified random sampling approach (Scheaffer et al. 1996). A mail survey was chosen because they can include complex questions, can be implemented to geographically dispersed groups, recipients can reply at their convenience, and they have a low potential for social desirability bias (Decker et al 2001). We used a 3-wave mail survey using a variation of the repeated mailing technique of Dillman (1978). Surveys were mailed to randomly selected landowners stratified among the 3 landscapes (eastern, central, western) in January, followed by 2 follow-up surveys to non-respondents about 4-8 weeks apart. After 3 attempts to contact landowners by mail we contacted a sub-sample of non-respondents by telephone to assess non-response bias. We used Likert-scale questions (Likert-scale numbers indicated by each response were used to calculate mean response scores) to assess beliefs and experiences with wildlife, concerns about moose, support for hunting, and acceptability of situations involving moose. To evaluate percentages, responses to questions about landowner beliefs and experiences were grouped ("Agree", “Neutral”, “Disagree”); responses to questions about landowner opinions about management were grouped (“Support”, “Neutral”, “Oppose”); and responses to questions about landowner concerns were grouped (“Acceptable”, “Not Acceptable/No Action”, “Not Acceptable/Action”).

The study protocol and survey was reviewed and approved by the Connecticut Wildlife Division, the Northeast Wildlife Damage Management Cooperative, and the Chair of the University of Connecticut, Office of Research Compliance, Institutional Review Board (IRB). The Chair deemed the survey exempt from further review thus no IRB number was awarded. Surveys were conducted in accordance with federal guidelines in which minors were excluded, results were not identifiable to individuals, and surveys involved no risks to individuals.

Hunter Survey

In 2008, a firearms hunting license could be purchased from any town clerk or their agents. We selected 31 town clerks (Figure 4.4) to distribute a moose survey to any resident or non-resident hunter purchasing a Connecticut firearms hunting license or combination hunting/fishing license. Towns and sampling period were selected based on highest volume of hunting license sales from 2004. Survey distribution occurred during 3 sample periods: January, April, and October 2008. These 3 periods were chosen to obtain a representative sample of each hunter group, since many hunters purchase a license to pursue game during a specific season, and the timing coincided with peak issuance. A packet containing a letter of instruction, a return envelope, and a specific number of surveys was mailed to the town clerk before each sample period. Number of surveys distributed to each town hall was based upon the volume of firearms hunting license sales from 2004. Town clerks were instructed to hand out a survey to every other individual that purchased a resident or non-resident hunting or combination hunting/fishing license. After completing the survey, town clerks collected the survey and mailed all completed surveys after each sampling period.

We generated questions to evaluate hunting activity, participation in outdoor-related activities, and hunter perceptions and opinions about Connecticut's moose population. We used a Likert-scale question to assess support for hunting. To evaluate percentages, responses were grouped ("support", "neutral", "oppose").

The study protocol and survey was reviewed and approved by the Connecticut Wildlife Division, the Northeast Wildlife Damage Management Cooperative, and the University of Connecticut Office of Research Compliance, Institutional Review Board (IRB). The Board deemed the survey exempt from further review thus no IRB number was awarded. Surveys were conducted in accordance with federal guidelines as minors were excluded, results were not identifiable to individuals, and surveys involved no risks to individuals.

Analysis

We treated ordinal-level (Likert Scale) data as interval-level data for these analyses. Previous studies have validated the use of such data in analysis of survey research (Nunnally and Bernstein 1994, Zinn and Andelt 1999, Daley et al. 2004). We calculated Levene's Test ($P < 0.05$) for Equality of Variances and Kolmogorov-Smirnov test of normality. Based on results of equality of variance and normality, we used the Kruskal-Wallis test ($P < 0.05$) for all analysis at the landscape level, and used the Mann-Whitney U test ($P < 0.05$) for comparisons between landowners and hunters. Pearson

Chi-square tests (*P*< *0.05*) were used to examine nominal-level variables and compare responses between respondents and non-respondents. All analyses were conducted using SYSTAT 12.0 (Systat Software, Inc., San Jose, California).

RESULTS

Respondent demographics

Landowner survey – Surveys were returned from 622 of 2,023 landowners (35.7% eastern, 31.3% central, 37.9% western). We received 66% of responses from the first mailing, 20% from the second mailing, and 14% from the final mailing. Among landscapes, there was no difference in gender (χ^2 = 3.44, P < 0.178) and age of respondents (χ^2 = 0.410, P < 0.999). Survey respondents were comprised of males (56.4%) and females (43.5%) with a mean age of 54.4 (SD = 14.7) years. We contacted 51 non-respondents by telephone to assess non-response bias for particular questions after 3 attempts to contact landowners by mail. Among landscapes, differences existed between the percentage of landowners that allowed hunting on their property (χ^2 = 30.0, P < 0.001). Hunting occurred more in western (16%, χ^2 = 13.6, P < 0.001) and eastern landscapes (14.7%, χ^2 = 20.3, P < 0.001) than central landscapes (3%).

Hunter Survey – Surveys were completed by 446 of 485 hunters (91.9%). We received 45.3% of responses from the first sample period, 35.9% from the second sample period, and 11.1% from the final sample period. Due to the high response rate, we did not assess non-response bias. Gender of hunters was primarily males (97.6%) with few females (2.4%), and mean age of hunters was 48.1 (SD = 12.5) years. Of different types of game animals hunted in the past 5 years, most hunted deer (65.2%), small game (50.4%), turkey (32.2%), waterfowl (21.7%), bear (7.0%), moose (3.6%), and other game animals (5.6%). Most hunters participated in consumptive and non-consumptive activities (Table 4.2).

Landowner beliefs and experiences with wildlife

Of 8 questions about beliefs and experiences with wildlife, most landowners agreed that wildlife and management were important, and mean response scores of landowners were similar across all landscape levels except for those questions that specified “hunting” (Table 4.3).

Knowledge about moose in Connecticut

Landowner survey – From a choice of three sketches depicting a deer, moose, and bear, landowners were asked which animal best represented an image of a moose. No differences existed among landscapes ($\chi^2 = 1.562$, $P = 0.458$) therefore responses were combined. Most landowners (90.3%) correctly selected the image of the moose, however 9.7% of landowners selected the deer.

Respondent and non-respondent opinions about the number of moose existing in Connecticut were not different ($\chi^2 = 2.316$, $P = 0.128$) and no adjustments were made. Among landscapes, no differences ($\chi^2 = 4.315$, $P = 0.634$) existed in landowner perceptions about how many moose exist in Connecticut, therefore responses were combined.

Landowner-Hunter comparisons –A similar proportion of landowners (63.9%) and hunters (67.4%) believed that < 100 moose existed in Connecticut ($\chi^2 = 1.31$, $P = 0.253$) (Table 4.2). However the proportion of landowners (18.5%) and hunters (27.7%) who believed that < 10 moose existed in Connecticut were not similar ($\chi^2 = 11.9$, $P = 0.001$) nor were the proportion of landowners (8.0%) and hunters (3.5%) who believed that > 500 moose existed ($\chi^2 = 8.6$, $P = 0.003$) (Table 4.2). The primary source of information influencing opinions about the size of the moose population was from other sources (33.1%) for landowners and personal experience (37%) for hunters (Table 4.2).

Opinions about moose

Landowner survey – Respondent and non-respondent opinions about the status of Connecticut's moose population ($\chi^2 = 5.997$, $P = 0.112$) and about the number of moose in Connecticut ($\chi^2 = 6.374$, $P = 0.095$) were not different and no adjustments were made. Among landscapes, no difference existed between the percentage of landowners that believed the moose population was increasing compared those that believe it was decreasing ($\chi^2 = 0.835$, $P = 0.659$), or the percentage that believed the moose population was too high compared to those that believed it was too low ($\chi^2 = 2.71$, $P = 0.257$), therefore responses were combined. Among landscapes, no difference existed between the percentage of landowners that would support designating wildlife viewing areas for moose watching ($\chi^2 = 2.68$, $P = 0.262$) therefore responses were combined. Most landowners (70.2%) would support designating wildlife viewing areas for moose watching.

Landowner-hunter comparisons – More than half (51.8%) of landowners and hunters (67.6%) believed Connecticut's moose population was increasing, but few landowners (3%) and hunters (4%) believed the moose population was too high (Table 4.2). The proportion of landowners and hunters who believed that the status of Connecticut's moose population was increasing or decreasing was different ($\chi^2 = 33.1$, P <0.001). However, the proportion of landowners and hunters who believed that the moose population in Connecticut was too low or too high was similar (χ^2 = 0.559, *P* = 0.455).

From a list of 3 activities proposed if moose were common in Connecticut, participation rates would be greatest for moose watching (62.1%) for landowners and hunting (50.8%) for hunters (Table 4.2). The proportion of landowners and hunters who would participate in watching moose (χ^2 = 60.8, *P* <0.001), photographing moose (χ^2 = 41.9, *P* <0.001), or hunting moose (χ^2 = 247.6, *P* <0.001) was different (Table 4.2). However, the proportion of landowners and hunters who would not participate in any moose activity if moose were common in Connecticut was similar (χ^2 = 0.057, *P* <0.811) (Table 4.2).

Interactions with moose

Landowner survey – Of landowners, 15% (*n* = 78) reportedly observed moose in 29 towns across Connecticut (Figure 5). Landowners reported the greatest number of moose sightings in the towns of Granby (*n* = 11), Hartland (*n* = 10), and Stafford (*n* = 9). In total, less than half of all sightings were of moose crossing the road (35%) (Table 4.2). Differences existed between the percentage of landowners that observed a moose in Connecticut (χ^2 = 14.3, *P* = 0.001) among landscapes (Table 4.4). Landowners observed more moose in eastern landscapes than central (χ^2 = 13.6, *P* < 0.001) and eastern landscapes (χ^2 = 6.07, *P* = 0.014), while no differences existed between landowners in central and eastern landscapes (χ^2 = 0.031, *P* = 0.860) (Table 4.4).

An additional 51 landowners reported seeing moose tracks or other sign and differences existed (χ^2 = 13.3, *P* = 0.001) at the landscape level (Table 4.4). Landowners in western landscapes reported observing more moose tracks and sign than those in central ($\chi^2 = 13.2$, $P < 0.001$) and eastern ($\chi^2 = 3.99$, $P = 0.046$) landscapes, while no differences were observed between eastern and central ($\chi^2 = 0.464$, $P = 0.496$) landscapes.

Among landscapes, differences existed in the number of moose-vehicle accidents landowners had experienced ($\chi^2 = 8.29$, $P = 0.016$) (Table 3). Landowners in western landscapes reported being in more moose-vehicle accidents than those in central ($\chi^2 = 7.45$, $P = 0.006$) landscapes, while no differences were observed between western and eastern ($\chi^2 = 2.71$, $P = 0.100$) or between eastern and central ($\chi^2 = 0.001$, $P = 0.979$) landscapes. Among landscapes, no differences existed in opinions of landowners who observed a moose in the past 2 years and described their encounter ($\chi^2 = 2.82$, $P = 0.830$). About 76.0% of landowners described their encounter as exciting, 10.0% as uneasy/concerned, 8.6% no opinion, and 5.7% as other.

Hunter survey – Of hunters, 20% ($n = 91$) reportedly observed moose in 36 towns across Connecticut (Figure 4.6). Hunters reported the greatest number of moose sightings in the towns of Hartland ($n = 11$), Thompson ($n = 4$), and Granby ($n = 4$). An additional 71 hunters reported seeing moose tracks or scat, of which 27 reports were from 14 of the same towns as sightings. Hunters reported seeing moose sign in an additional 13 towns where moose were not actually observed. Of hunters who observed a moose in the past 2 years and described their encounter ($n = 102$), 72.5% described it as exciting, 17.6% had no opinion, 4.9% were uneasy/concerned, and 4.9% as other.

Landowner concerns with moose

Among landscapes, mean response scores regarding landowner concerns with moose were not different for health, safety, or damage-related issues ($H = 0.059$-2.115, 0.742 > P > 0.347) and were combined for analysis (Table 4.5). The majority of landowners were not concerned about moose in Connecticut except if it involved being in a moose-vehicle accident (Table 4.5).

Moose Population Management:

Landowner survey – Among landscapes, mean response scores regarding moose population management were not different for any of the population scenarios given (H = 1.44-5.59, 0.487 > P > 0.061) and responses were combined for further analysis (Table 4.6). A third of landowners (31%) supported using hunting as a method to control moose populations in Connecticut based on their current level of concern. However, support was highest if hunting was carefully regulated and controlled by the state (54%) or if the moose population and number of moose-vehicle accidents were increasing in Connecticut (54%). The majority of hunters (83-88%) supported hunting under all scenarios (Table 4.6). Of landowners who indicated that they primarily supported hunting to control moose populations, the greatest percentage of respondents (18.1%) believed "regulated hunting is a legitimate method to control moose population growth" (Table 4.7).

Of landowners who indicated that they primarily opposed hunting to control moose populations, the greatest percentage of landowners (16.3%) believed "moose are not a threat to human safety at their current level" and the greatest percentage of landowners (24.5%) selected trap and relocate moose within the state as the most acceptable alternative to hunting (Table 4.7).

Landowner-Hunter comparisons – The proportion of landowners and hunters who supported hunting was different; " if it was carefully regulated and controlled by the state" (U = 53,194, χ^2 = 211.53, P <0.001), "if they knew that the moose population would be maintained at its current level" (U = 49,524, χ^2 = 206.22, P <0.001), and "if the moose population and number of moose-vehicle accidents was increasing in Connecticut" (U = 18,731, χ^2 = 268.01, P <0.001) (Table 4.6).

Landowner opinions about roadside sightings and moose-vehicle accidents

At the landscape level no differences existed (H = 3.7-5.8, 0.15 > P > 0.054) in opinions about roadside sightings (Table 4.8). If the potential number of moose seen along busy highways in Connecticut increased from occasionally to frequently, the percentage of landowners who deemed "it not acceptable and some action should be taken" increased from 51.0% and 74.1% (Table 4.8, Figure 4.7).

At the landscape level no differences existed (H = 0.61-2.8, 0.23 > P > 0.73) in opinions about moose-vehicle accidents (Table 4.8). If the potential number of moose-vehicle accidents increased from 1 to > 10, the percentage of landowners who deemed "it not acceptable and some action should be taken" increased from 37.5% to 75.8% (Table 4.8, Figure 4.8).

At the landscape level no differences existed (H = 2.2-3.0, 0.33 > P > 0.22) in opinions about fatalities resulting from a moose-vehicle accident (Table 4.8). If the potential number of human fatalities from moose-vehicles accident increased from 1 to > 10 fatalities per year, the percentage of landowners who deemed "it not acceptable and some action should be taken" increased from 62% to 86.2% (Table 4.8, Figure 4.9).

DISCUSSION

Few landowners hunted or permitted hunting on their property. However, most landowners agreed that they notice wildlife, and observing and learning about wildlife was important to them and most were supportive of designating wildlife viewing areas for moose. Landscape was influential on, whether landowners allowed hunting on their property, beliefs and experiences with wildlife when "hunting" was involved, and on direct interactions with moose and MVA. Although experiences with moose differed at the landscape level, knowledge, opinions about moose and moose management, and concerns about moose were similar.

We found in Connecticut, that landowner and hunter knowledge about moose abundance was limited, as was similarly hypothesized in Massachusetts (Vecellio et al. 1993). A small number of landowners (n = 18) and hunters (n = 28) believed no moose existed in Connecticut. Landowners indicated the main source of information leading to their estimate about how many moose existed in the Connecticut came from non-DEEP sources, while hunters were influenced by personal experience and DEEP communications. It is not surprising that 20-30% of landowners and hunters believed so few moose existed, seeing only a small percentage had ever observed a moose in Connecticut.

Many landowners and hunters had no opinion about whether the moose population was increasing or decreasing or about how many moose should exist in Connecticut. Lack of familiarity and lack of interest in moose, likely led to lack of participation (low response rates) in the landowner survey and lack of opinions about moose in Connecticut. Using public opinion surveys, Riley and Decker (2000) found a large portion of people lacked opinions about cougars in Montana. Riley and Decker (2000) suggested that lack of opinions may indicate; 1) a lack of general concern about cougars in the everyday lives of residents, 2) stakeholder perceptions that managers do not listen to stakeholder concerns, 3) or trust in delegation of decision making in the hands of the managers.

Overall, the majority of landowners had few concerns about moose. However, landowners had the greatest concern about being involved in a moose-vehicle accident, although fewer than 2% had ever been involved in one. As stakeholders, they perceived the potential for human injury as real. Regardless of the level of concern regarding moose, fewer than half of landowners supported using hunting as a method to control moose populations in Connecticut based on current population levels, as opposed to hunters who were strongly supportive. Landowner support for hunting increased if landowners knew hunting would be carefully regulated and controlled by the state or if the likelihood of a human fatality was greater for a moose-vehicle accident than a deer-vehicle accident. However, as the hypothetical number of roadside sightings of moose, moose-vehicle accidents, or the number of human fatalities resulting from a moose-vehicle accident increased, the percent of landowners who indicated that it was unacceptable to them increased. The collective ability for humans to accept the presence and consequences of any wildlife species will eventually define the wildlife acceptance capacity (WAC) (Decker and Purdy 1988) for that species. However, in Anchorage, Alaska, where moose populations have exceeded habitat carrying capacity (which is often greater than WAC), only half of residents surveyed supported moose hunting (Whittaker et al. 2001). Acceptance of hunting among certain stakeholders may be controlled more by core differences in basic beliefs about hunting, which are based on fundamental value orientations toward use or protection of wildlife (Fulton et al. 1996, Zinn et al. 1998).

In Massachusetts, an average of 4 moose-vehicle accidents occurred between 1990–1994 (B. Woytek, Massachusetts Division of Fisheries and Wildlife, personal Communication). The average number of moose-vehicle accidents per year increased to 27, between 2000–2008 (SD = 13.5) (S. Christensen, Massachusetts Division of Fisheries and Wildlife, personal communication) and the population was estimated between 800-1,800 moose (DeStefano and Wattles 2010). McDonald (2004) made recommendations on how to manage increasing moose populations in Massachusetts, however resident concerns about moose and moose-vehicle accidents apparently have not exceeded WAC, seeing that the statutory changes required to implement such management actions have not been made (S. Christensen, personal communication). Connecticut had not experienced any moose-vehicle accidents until 1995, however between 2003–2009, an average of 2.3 moose-vehicle accidents per year has occurred (LaBonte, unpublished data). Comparing moose sighting records and moose-vehicle accidents reports between Massachusetts and Connecticut, it appears Connecticut could experience a population expansion similar to Massachusetts.

It can be expected that as Connecticut's moose population continues to increase, so will the number of moose-vehicle accidents as well as the likelihood of human fatality resulting from a moose-vehicle accident. If the frequency of moose sightings along roads increases, support for controlling moose populations will increase, regardless of the number of moose-vehicle accidents or human fatalities. Lee and Miller (2003) reported similar results regarding elk in urban areas of Flagstaff, Arizona.

We expect a reduction in the public's capacity for moose given further conflicts, the need for increased public education, increased public understanding of the role of lethal management to protect humans, and being proactive rather than reactive regarding moose management. Education efforts should be undertaken to increase public awareness about moose in Connecticut. Posting warnings on Department of Transportation Variable Message Boards (VMB's) about moose in the area, erecting moose-crossing signs in areas of documented moose activity, and providing talks for various stakeholder groups are three approaches to increase public awareness. Although, using VMB's and erecting signs may or may not have limited effects on changing driving behavior, these actions should alert drivers who may otherwise be unaware that moose are present in the state. For pro-active management to be accepted in the state, a strong educational effort is going to be required to manage populations before levels exceed WAC. Taking a pro-active approach to moose management in southern New England may be a departure from the norm, but may be a responsible choice if the alternative is managing by road-kill (McDonald 2004).

MANAGEMENT IMPLICATIONS

Human dimensions surveys are valuable tools that can be used to better understand experiences and opinions of various stakeholder groups. From our survey results it is apparent that educational efforts should be undertaken to increase public and hunter awareness about moose in Connecticut. It is important that residents and hunters are aware that opportunities to view moose currently exists in one of the most densely human populated states in the United States and moose can also pose a serious threat to public safety in the way of moose-vehicle accidents. Providing more public presentations across the state and increasing educational efforts will also be essential for gaining support for managing moose in the future. Developing a successful moose management plan that will be acceptable to most stakeholders will be critical for success.

Table 4.1. Human densities and landscape level (Eastern, Central, Western) characteristics in Connecticut, 2008.

Location	Eastern	Central	Western
Number of towns	(n = 16)	(n = 13)	(n = 20)
Population	(79 people/km^2)	(185 people/km^2)	(71 people/km^2)
% Forest	65.4	29.8	67.9
% Commercial/residential	14.2	43.2	11.7
% Turf/agriculture	12.4	21.1	12.6
% Wetlands	4.6	2.8	3.8
% Water	2.3	1.8	3.3
% Other	1.1	1.3	0.7

Table 4.2. Landowner and hunter opinions about the moose population in Connecticut, USA, 2008.

Survey question	Percent of respondents	
	Landowner	Hunter
Number of moose (*n*)	590	408
0	3.0	6.9
<10 [a]	18.5	27.7
<100 [a]	63.9	67.4
100-499	28.0	29.0
> 500	8.0	3.5
Source of information (*n*)	582	343
Newspaper	25.6	17.0
Personal Experience	19.1	39.0
Television	15.1	11.0
DEEP communication	4.3	20.0
Radio	2.8	1.0
Other	33.1	13.0
Status of moose population (*n*)	606	430
Increasing	51.8	67.6
Decreasing	7.8	<1.0
Stable	10.0	11.6
No opinion	30.4	20.0
Opinion of moose population (*n*)	604	427
Too high	3.0	3.9
Too low	25.9	40.6
Just right	15.7	19.2
No opinion	54.9	36.1
Activities would participate in (*n*)	626	404
Watching moose	62.1	33.8
Photographing moose	50.7	27.5
Hunting moose	10.7	50.8
Other	2.0	1.0
None	20.0	19.0
Moose sightings (*n*)	78	91
In yard	14.0	15.0
Outside yard	29.0	40.0
Crossing road	35.0	40.0
Other	22.0	5.0

[a] Includes all respondents who indicated 0 or <10.

Table 4.3. Landowner beliefs and experiences about wildlife in Connecticut, USA, 2008.

Beliefs and experiences about wildlife	**% Response**[a]												Mean response scores[b]			***H***[c]	***P***[c]	***n***
	Agree			Neutral			Disagree			No opinion								
	C	E	W	C	E	W	C	E	W	C	E	W	C	E	W			
I notice birds and wildlife around me daily	98	99	96	1	0	2	1	1	1	0	0	1	1.65	1.77	1.70	4.60	0.101	626
Observing and learning about wildlife is important to me	88	92	89	10	7	7	2	1	3	0	0	1	1.34	1.47	1.40	3.12	0.210	624
Hunting animals for any purpose should not be permitted	19	12	22	22	16	12	58	71	65	2	2	1	-0.54	-0.89	-0.68	7.66	**0.022**	623
It is important to manage some wild animal populations	84	86	86	9	5	9	6	8	4	1	1	1	1.08	1.16	1.18	3.09	0.214	622
Wild animal populations should be managed for the benefit of all people	68	69	74	16	16	13	14	13	13	1	3	1	0.78	0.84	0.81	0.38	0.826	620

Participation in hunting helps people appreciate wildlife and natural processes	36	53	44	23	23	15	36	22	37	4	3	4	-0.01	0.40	0.03	8.62	**0.013**	623
If wildlife populations are abundant, it is ok to use them as a natural renewable resource	53	65	55	22	15	24	19	17	17	6	3	5	0.45	0.71	0.49	5.13	0.077	613
Regulated hunting is an acceptable use of a natural resource	65	76	69	15	9	12	16	13	17	4	2	3	0.63	0.94	0.70	9.88	**0.007**	621

E = Eastern, C = Central, W = Western

[a] Likert scale ranged from -2 ("Strongly disagree") to 2 ("Strongly agree"). To evaluate percentages, responses were truncated into "Agree, Neutral, Disagree."

[b] Not included in analysis are the number of respondents who choose "No opinion."

[c] *H* and *P* values for Kruskal-Wallis Test Statistic comparison between eastern, central, and western groups.

Table 4.4. Landowner interactions with moose in Connecticut, USA, 2006-2007.

Moose-human interactions	% Response Yes C	E	W	No C	E	W	χ^2	P^a
Observed Moose	12.0	12.6	27.0	88.0	87.4	73.0	14.3	0.001
In Yard	1.5	4.6	5.3	98.5	95.4	94.7	5.56	0.062
Outside Yard	3.8	3.4	13.7	96.2	96.6	86.3	13.55	0.001
Crossing Road	5.8	2.3	13.7	94.2	97.7	86.3	9.88	0.007
Other	3.5	5.7	5.3	96.5	94.3	94.7	1.26	0.531
Observed Tracks/scat	7.8	10.0	21.8	92.2	90.0	78.2	13.3	0.001
Moose-vehicle accident	1.0	1.0	4.9	99.0	99.0	95.1	8.29	0.016

E = Eastern (n = 87), C = Central (n = 343), W = Western (n = 95)

[a] χ^2 and P values for Pearson Chi-square comparison between eastern, central, and western groups

Table 4.5. Landowner concerns about moose interactions in Connecticut, USA, 2008.

Concerns about moose	**% Response**				**Mean response scores**[a]	***H***[b]	***P***[b]
	No concern	Some concern	Very concerned	No opinion			
Encountering a moose	67.4	24.9	4.0	3.7	1.47	1.263	0.532
The cost of residential property damage caused by moose	57.2	30.9	4.9	7.1	1.61	2.115	0.347
Being injured in a motor vehicle accident that involves a moose	28.0	50.7	18.6	2.8	2.33	1.385	0.500
Potential problems that moose may cause to the ecosystem	52.5	31.3	4.9	11.3	1.66	0.596	0.742
Overall current level of concern related to moose	57.3	34.6	3.4	4.7	1.58	0.662	0.718

[a] Likert scale ranged from 1 ("Not concerned") to 4 ("Very concerned"). To evaluate percentages, "slightly concerned" and "somewhat concerned" responses were truncated into "Some concern"

[b] *H* and *P* values for Kruskal-Wallis Test Statistic comparison between eastern, central, and western groups

Table 4.6. Landowner and hunter opinions about managing moose populations using hunting in Connecticut, USA, 2008.

Concerns about moose	**% Response**						**Mean response scores**[a]						
	Support		Neutral		Oppose				H^b	P^b	U^c	P^c	χ^2
	Land	Hunt	Land	Hunt	Land	Hunt	Land	Hunt	Land	Land			
Based on your current level of concern?	31	*NA*	29	*NA*	40	*NA*	-0.23		2.05	0.35			
If your level of concern increases?	47	*NA*	25	*NA*	29	*NA*	0.20		3.98	0.13			
If hunting were carefully regulated and controlled by the state?	54	88	22	6	24	6	0.34	1.41	2.82	0.24	53,194	0.00	211.5
If you knew that the moose population would be maintained at its current level?	41	83	30	8	29	9	0.09	1.23	2.69	0.26	49,524	0.00	206.2
If you knew that hunting is currently allowed in other New England states?	41	*NA*	30	*NA*	29	*NA*	0.10		5.59	0.06			
If you knew the likelihood of a human fatality was greater?	54	85	26	8	21	7	0.44	1.37	1.44	0.48	18,731	0.00	268.0

[a] Likert scale ranged from -2 ("Strongly oppose") to 2 ("Strongly support"). To evaluate percentages, "strongly support" and "support" were truncated into "support," and "oppose" and "strongly oppose" were truncated into "oppose."

[b] H and P values for Kruskal-Wallis Test Statistic comparison between eastern, central, and western groups
[c] U and P values for Mann-Whitney U test between landowners and hunters
[d] If you knew the likelihood of a human fatality was greater for a moose-vehicle accident than a deer-vehicle accident and that the moose population and number of moose-vehicle accidents were increasing in Connecticut?
NA = Not asked on survey

Table 4.7. Landowner responses regarding reasons why they primarily supported or opposed hunting to control moose populations and acceptable alternatives to hunting in Connecticut, USA, 2008.

Primarily supported hunting	***n***	**% Respondents**
Regulated hunting is a legitimate method to control moose population growth	306	18.1
Moose threaten human safety	254	15.1
DEEP officials are well trained to handle problems associated with moose	252	14.9
Moose population is too high or may become too high	244	14.5
Moose cause damage to crops or property	244	14.5
Want the opportunity to hunt moose	222	13.2
Don't know	101	6.0
Other	63	3.7
Primarily opposed to hunting		
Moose are not a threat to human safety at their current level	211	16.3
Moose do not cause enough damage to warrant management	205	15.8
Moose population is too low and does not warrant management	198	15.3
Do not support hunters killing moose	190	14.6
Disagree with hunting	181	14.0
Do not support DEEP killing moose	176	13.6
Do not know	85	6.6
Other	51	3.9
Acceptable alternatives to hunting		
Trap and relocate within state	239	24.5
Birth Control	200	20.5

Use sharpshooters under strictly controlled setting	174	17.8
No action	156	16.0
Trap and kill	154	15.8
Other	53	5.4

Table 4.8. Landowner concerns about moose interactions in Connecticut, USA, 2008.

Concerns about moose	**% Response**													
	Acceptable			Not acceptable/no action			Not acceptable/action			**Mean response scores[a]**				
	C	E	W	C	E	W	C	E	W	C	E	W	***H*[b]**	***P*[b]**
A moose is on or near a busy highway occasionally	35.6	39.2	23.7	13.9	13.4	19.6	50.5	47.4	56.7	3.31	3.29	3.60	3.742	0.154
Moose are frequently on or near busy highways	14.6	19.8	10.2	10.9	14.6	9.2	74.5	65.6	80.6	4.13	4.01	4.36	5.837	0.054
1 Moose-vehicle collision occurs each year statewide	38.1	34.4	31.6	21.5	36.5	34.7	40.4	29.2	33.7	3.16	3.05	3.11	0.618	0.734
2-5 Moose-vehicle collisions occur each year statewide	26.5	26.6	20.4	15.5	18.1	18.4	58.0	55.3	61.2	3.80	3.78	3.93	1.009	0.604
6-10 Moose-vehicle collisions occur each year statewide	18.1	21.3	10.5	15.4	7.9	14.7	66.5	70.8	74.7	4.14	4.26	4.40	2.878	0.237
>10 Moose-vehicle collisions occur each year statewide	13.2	17.8	9.4	12.4	7.8	8.3	74.4	74.4	82.3	4.39	4.49	4.68	2.746	0.253
A human fatality results from a motorist hitting a moose in Connecticut	16.7	20.0	10.5	21.0	24.4	23.2	62.4	55.6	66.3	4.08	3.82	4.23	2.964	0.227
2-5 human fatalities result from a motorist hitting a moose in Connecticut	10.8	13.3	6.3	14.2	10.0	10.4	75.0	76.7	83.3	4.52	4.56	4.69	3.069	0.216

6-10 human fatalities result from a motorist hitting a moose in Connecticut	8.0	11.1	4.2	10.4	7.8	8.3	81.6	81.1	87.5	4.74	4.78	4.93	2.235	0.327
>10 human fatalities result from a motorist hitting a moose in Connecticut	7.2	8.9	2.1	7.7	4.4	7.3	85.1	86.7	90.6	4.87	4.99	5.09	2.226	0.329

E = Eastern, C = Central, W = Western

[a] Likert scale was 1 (“Acceptable”), 2 (“Not acceptable/no management action taken”), 3 (“Not acceptable/action should be taken”).

[b] *H* and *P* values for Kruskal-Wallis Test Statistic comparison between eastern, central, and western groups

Figure 4.1. Distribution of unsolicited moose sightings reported to the Department of Energy and Environmental Protection by the public in Connecticut, USA, 1992-2002 (Kilpatrick et al. 2003).

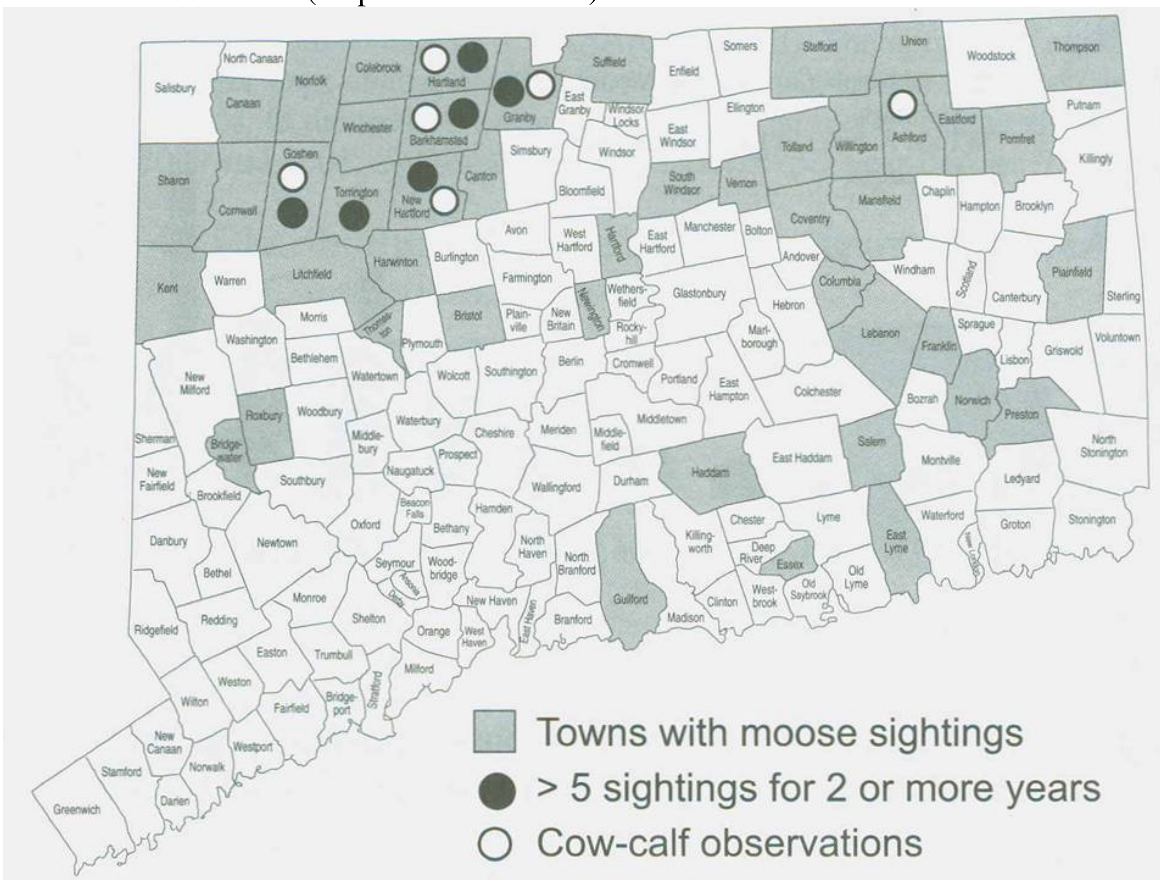


Figure 4.2. Distribution of moose sightings reported to the Department of Energy and Environmental Protection on annual deer hunter questionnaires in Connecticut, USA, 1996-2007 (LaBonte et al. 2008).

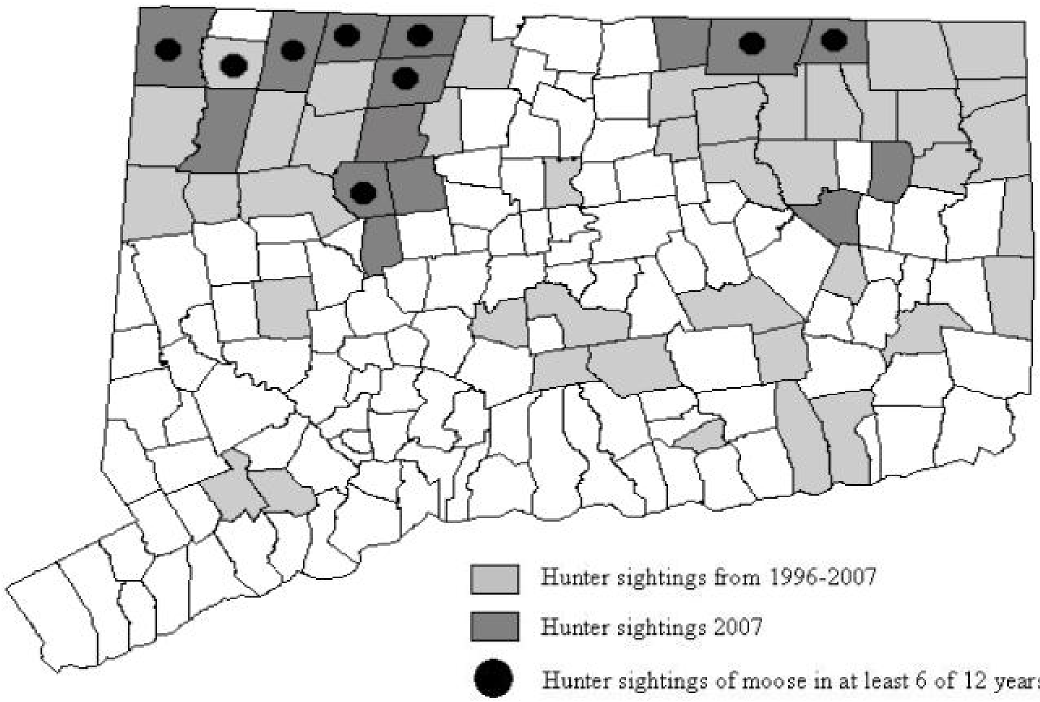


Figure 4.3. Towns selected for landowner survey, Connecticut, USA, 2008.

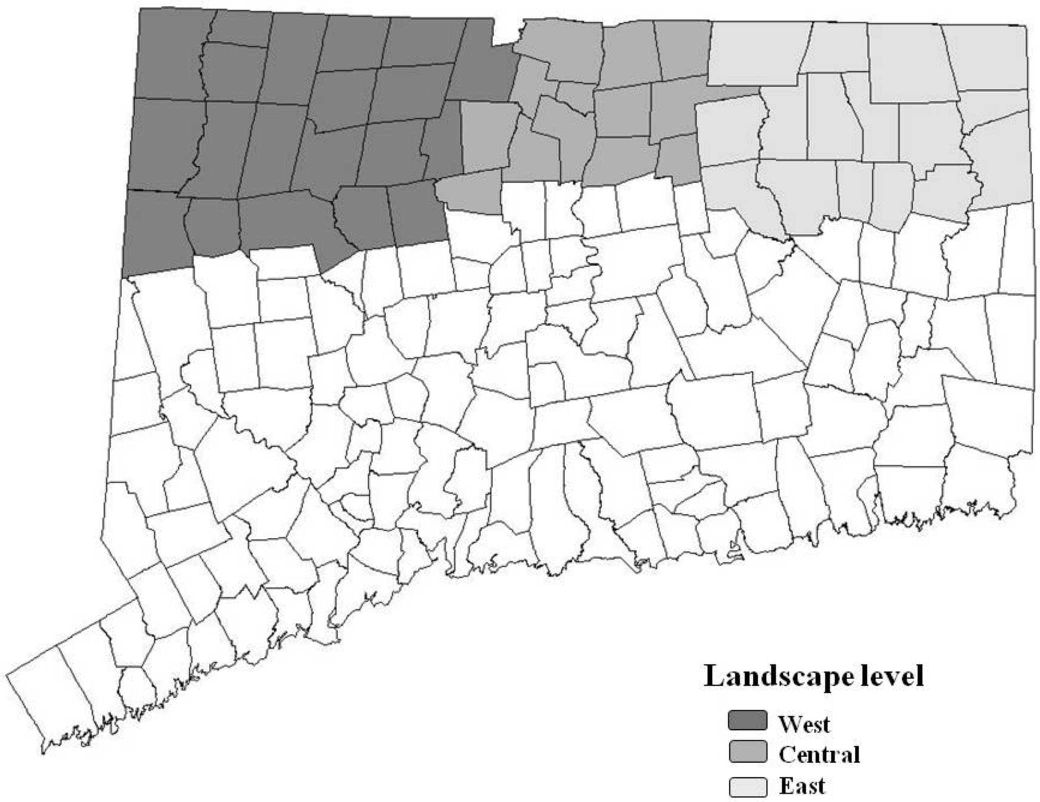


Figure 4.4. Town halls selected to distribute hunter surveys in Connecticut, USA, 2008.

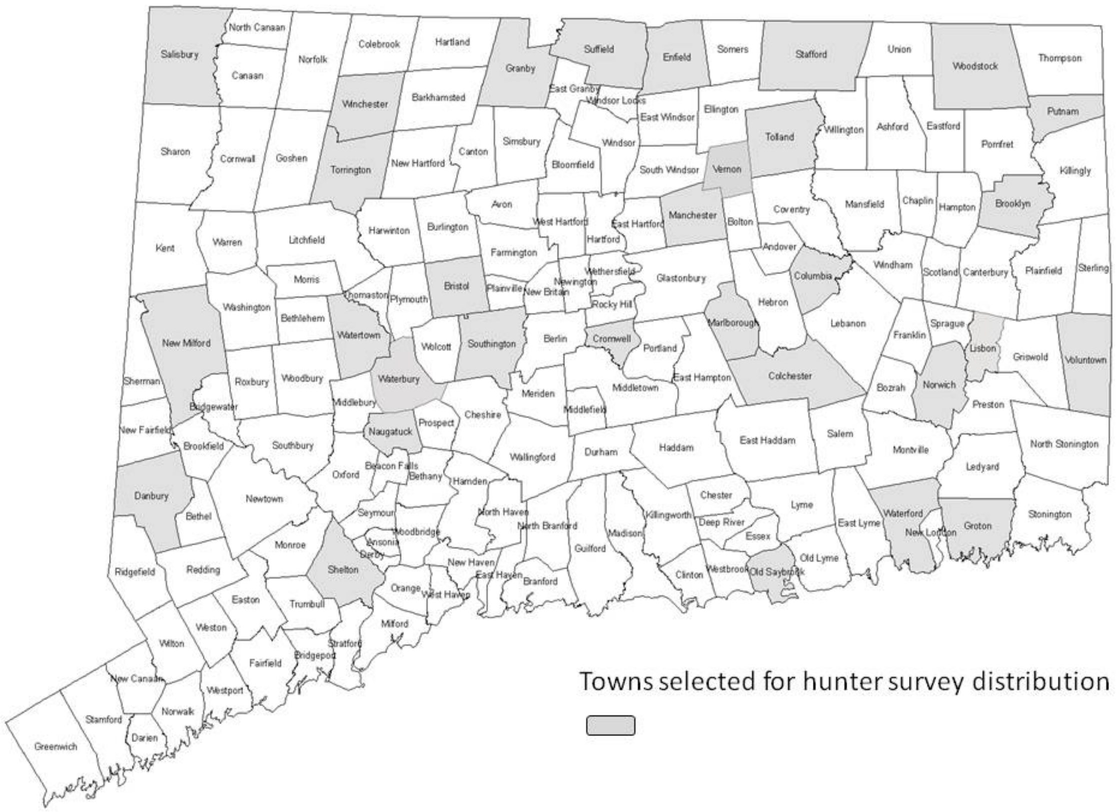


Figure 4.5. Sightings of moose based on landowner survey in Connecticut, USA, 2006-2007.

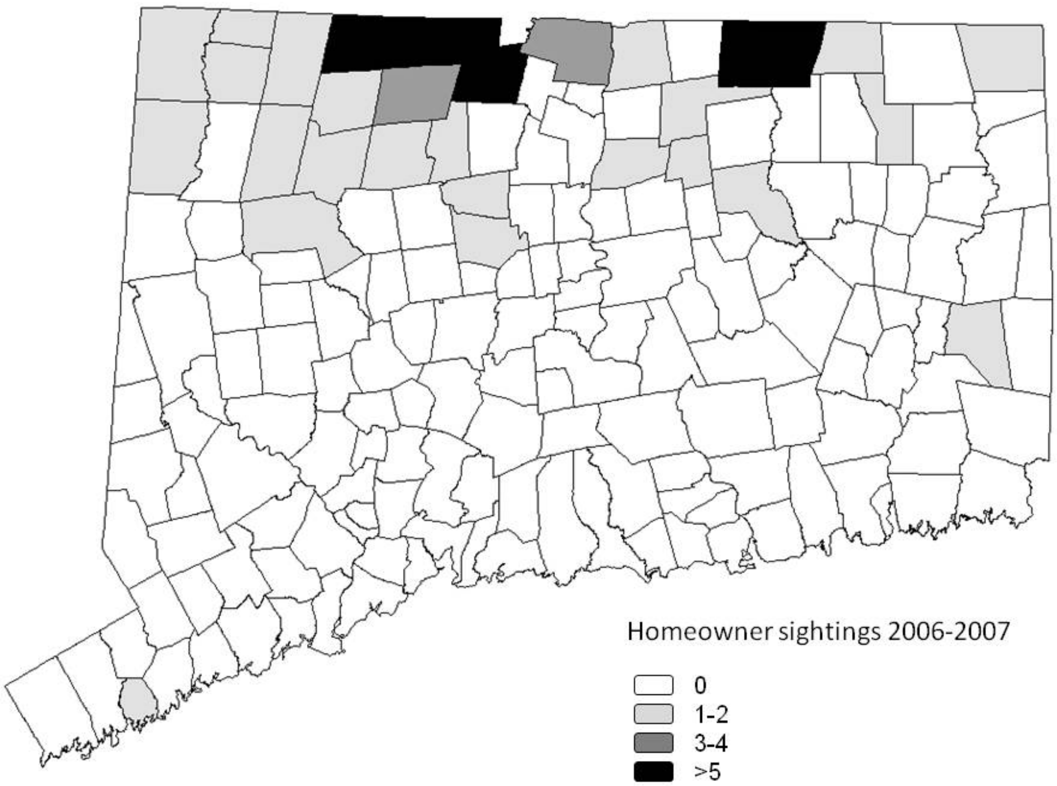


Figure 4.6. Sightings of moose based on hunter surveys in Connecticut, USA, 2006-2007.

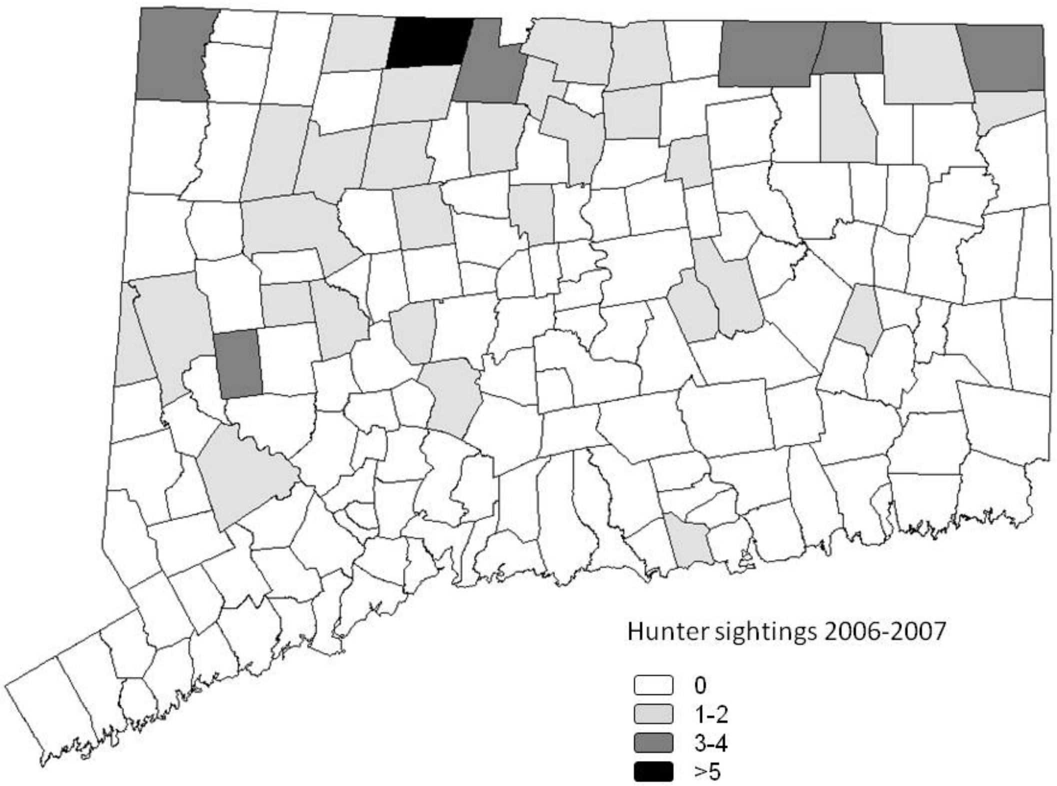


Figure 4.7. Landowner opinions about potential roadside sightings of moose in Connecticut, USA, 2008.

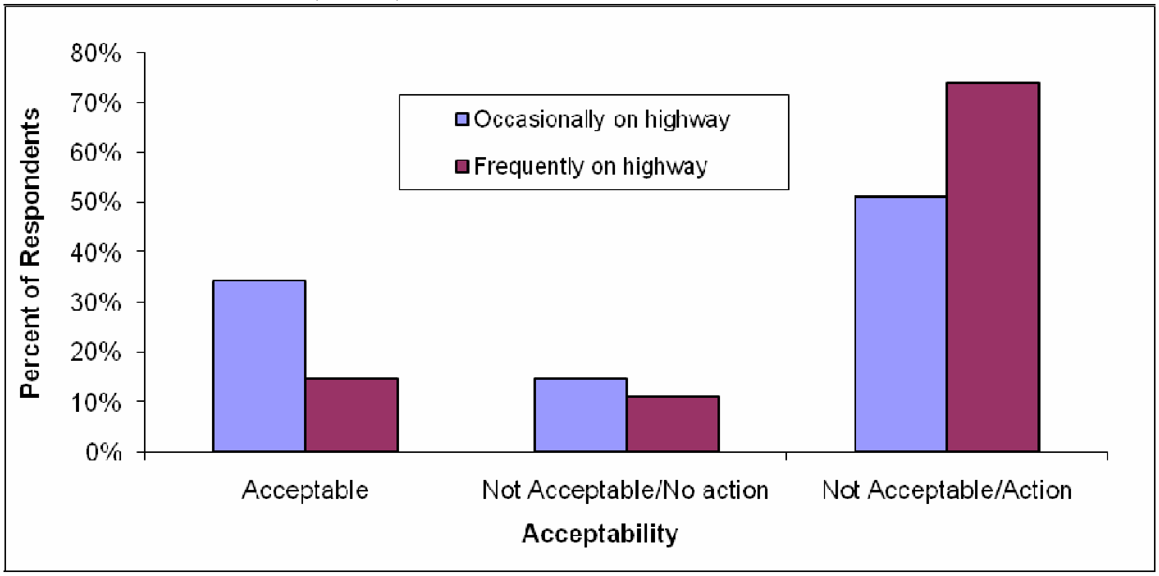
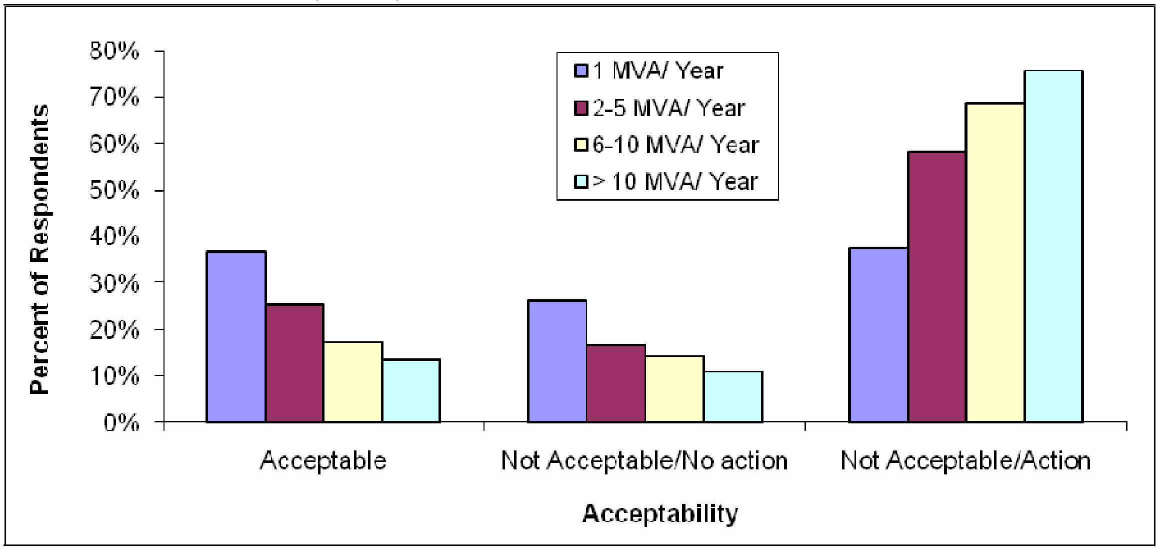
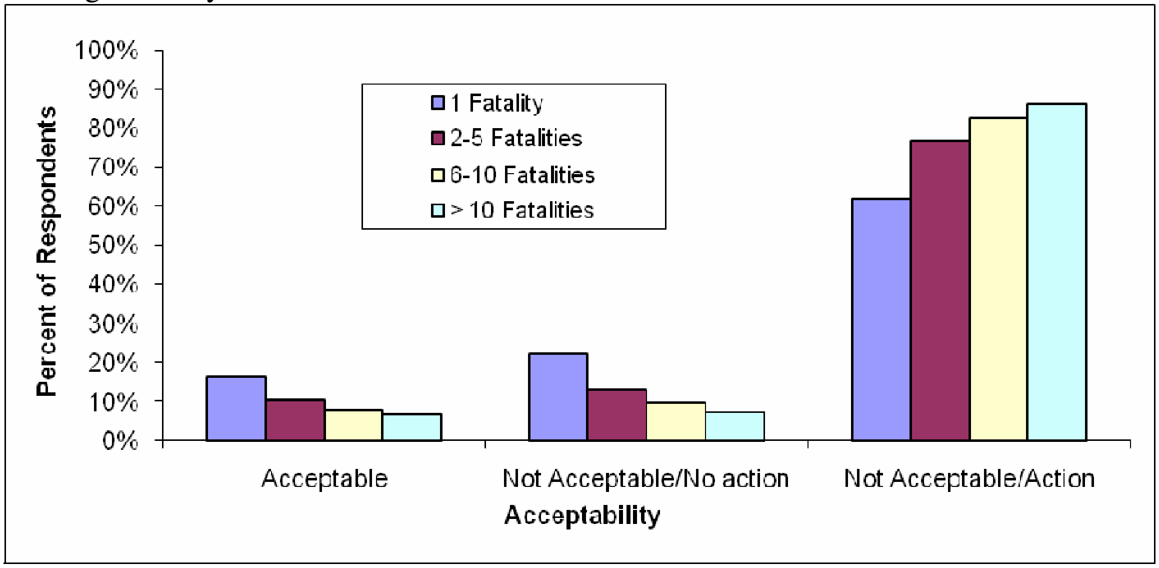


Figure 4.8. Landowner opinions about frequency of potential moose-vehicle accidents in Connecticut, USA, 2008.



MVA = Moose vehicle accident

Figure 4.9. Landowner opinions about frequency of potential moose-vehicle accidents causing a fatality in Connecticut, USA, 2008.



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CHAPTER 5

DEER HUNTER OPINIONS ABOUT MOOSE AND MOOSE MANAGEMENT IN CONNECTICUT

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ABSTRACT: Moose populations in northern New England have been increasing since the 1970s. These increasing northerly populations have lead to an increasing number of moose in southern New England in recent years. These increasing moose populations present new challenges for wildlife managers who need to balance the conservation of resources and the satisfaction of the stakeholders who use them. Understanding stakeholder attitudes is important when developing outreach and management programs and the need to balance stakeholder preference with population objectives. Our objectives were to assess hunter distribution, hunter days spent in the field as it relates to moose-hunter interactions, hunter opinions of the moose population, interest in moose hunting, and input on moose management strategies. Distribution of deer hunters throughout the state was similar, but interactions with moose occurred mainly in northern Connecticut. The majority of hunters (66.5%) believed the moose population was increasing, were not concerned about the moose population expanding in Connecticut

(62.7%), and were interested in hunting moose if they became common (86%). More than half of hunters (55%) were supportive of using moose hunting to control population growth at the current time, but would prefer a restriction on the harvest of cow moose (43.6%) and permit availability (59.9%). Hunter insight will be beneficial for determining which areas should be considered for hunting, and hunter preference for season lengths and hunting methods for managing moose, and for devising an equitable hunter selection method.

KEY WORDS: *Alces alces*, moose, hunter opinions, management

Alces 00(0): 000–000

Moose in northern New England were abundant in the 1600s. By the 1800s moose populations had declined due to habitat loss and unregulated hunting (Alexander 1993, Vashon 2008, Snyder and Rines 2010). In Massachusetts and Connecticut, moose are believed to have been extirpated in the 1800s (Goodwin 1935, Vecellio et al. 1993). Changes in land use, lack of significant predators, and restrictive hunting laws allowed for moose populations to increase through the late 1900s (Alexander 1993, Vecellio 1993, Kilpatrick et al. 2003, Vashon 2008). Hunting seasons were established in Maine (1980), New Hampshire, (1987), and Vermont (1993) to manage moose populations that now exceed 40,000 (Alexander et al. 1998, Vashon 2008, Snyder and Rines 2010). Increasing moose populations in northern New England have led to a southerly expansion into Massachusetts (DeStefano and Wattles 2010) and Connecticut (LaBonte and Kilpatrick 2006).

Expanding moose populations present new challenges for wildlife managers who need to balance the conservation of resources and the satisfaction of the stakeholders who use them (Boyle et al 1993). Moose are considered a renewable resource, that provide many benefits and socio economic-advantages (Timmermann and Rodgers 2005). All moose have some intrinsic economic value associated with consumptive and non-consumptive users (Schwartz and Bartley 1991). However, populations can reach a point where they can produce adverse consequences in the form of human conflicts such as moose-vehicle accidents (MVA's) and ecological damage (Timmermann and Rodgers 2005). Understanding, educating, and balancing stakeholder attitudes with agency objectives is important when developing educational outreach and management programs (Teel et al. 2002).

Most human dimensions research has focused on evaluating hunter opinions and hunter satisfaction (Manfredo 1989) and little information about moose exists outside of studies in Alaska (Fulton and Hundertmark 2004) and Canada (Wedeles et al. 1989, Hansen et al. 1995, Ericsson 2003). Fulton and Hundertmark (2004) found that assessing and responding to hunter beliefs regarding Alaska moose hunting regulations was key to developing adaptive management strategies that could meet their social and biological objectives. Wedeles et al. (1989) evaluated hunter opinions about the selective harvest system in Ontario leading to several changes to the system and increased communication with the public. A similar study conducted by Hansen et al. (1995) in Ontario identified several differences in opinions among hunters with many aspects related to moose hunting. Many of these hunter surveys have aided managers in making informative moose management decisions regarding season dates, selective harvest systems, quotas, and regulation changes (Wedeles et al. 1989, Hansen et al. 1995, Fulton and Hundertmark 2004).

No information exists regarding hunter perceptions about moose or potential moose management actions along the southern extent of moose range where populations have recently been re-established and hunting has not historically occurred. As moose populations increase along the southern extent of their range, the need to develop management strategies that are both effective and acceptable to hunters becomes increasingly important. We assessed hunter distribution, hunter-days spent afield as it relates to moose-hunter interactions, hunter opinions of the moose population, interest in moose hunting, and input on moose management strategies.

STUDY AREA

The study area was the state of Connecticut (12,548.5 km^2) which was the fourth most densely populated state in the United States (Connecticut Economic Resource Center 2006). Connecticut is bounded on the south by Long Island Sound, and by the states of Rhode Island to the east, Massachusetts to the north, and New York to the west. The human population was about 3,500,000 (278 people/ km^2) (Connecticut Economic Resource Center 2010).

Historic accounts suggest that moose existed in Connecticut prior to the eighteenth century (Trumbull 1797, DeForest 1964). However, Goodwin (1935) noted that at the beginning of the eighteenth century there were no records of moose in Connecticut. According to the Connecticut State Archaeologist, no archaeological deposits of moose exist (N. Bellantoni, Connecticut State Archeologist, personal communication) indicating that moose, if ever native, likely existed in low numbers.

Between 1916 and 1956 sightings of moose in Connecticut were reported by the public on a few occasions (Connecticut Wildlife 2000). On 18 September 1956, the

Connecticut Department of Energy and Environmental Protection (DEEP) passed an emergency regulation that gave full protection to moose found in Connecticut. From the 1980s to the early 1990s wandering moose occasionally were reported in the state; however, there was no evidence that a resident population existed in Connecticut (Kilpatrick et al. 2003). In 1992, the DEEP began documenting all credible public moose sightings and moose-vehicle accidents (MVA's) and in 1996 a question was added to the annual deer hunter questionnaire asking hunters to report all sightings of moose during the hunting season. In 1998, the DEEP, Wildlife Division, adopted a directive (DEEP2431-D1) that outlined procedures for responding to problem moose situations in Connecticut that included hazing, capture and relocation, and euthanization.

In 1995, the first documented MVA occurred. From 1995-2002, an average of 1 MVA occurred every other year; then increased to an average of 2 MVA per year from 2003-2009. In 2000, a resident moose population was established (Kilpatrick et al. 2003) and public sightings indicated Connecticut had a moose population that was expanding in size and distribution. Using an empirical model, the moose population in Connecticut was conservatively estimated at 64 moose in 2004 (LaBonte and Kilpatrick 2006). The first human fatality resulting from a MVA occurred in 2007 (Howard Kilpatrick, Department of Energy and Environmental Protection, Wildlife Division, personal communication).

METHODS

Addresses of all hunters who purchased a deer permit in 2007 (n = 31,753) were obtained from the Connecticut DEEP, License and Revenue office. A 3 wave mailing was performed using a variation of the repeated mailing technique of Dillman (1978).

We calculated minimum sample size required for each area based on a random sampling approach (Scheaffer et al. 1996). The study protocol and survey was reviewed and approved by the Connecticut Wildlife Division, the Northeast Wildlife Damage Management Cooperative, and the Chair of the University of Connecticut, Office of Research Compliance, Institutional Review Board (IRB). The Chair deemed the survey exempt from further review thus no IRB number was awarded. Surveys were conducted in accordance with federal guidelines in which minors were excluded, results were not identifiable to individuals, and surveys involved no risks to individuals. Surveys were initially mailed to randomly-selected resident hunters from the list in January 2008. Two follow-up surveys were mailed to initial non-respondents about 4-8 weeks apart using. Follow-up phone surveys were conducted to assess non-response bias after 3 unsuccessful attempts to contact hunters by mail.

We calculated standard error for all responses (Ebdon 1985). To assess differences in frequency of responses among questions between respondents and non-respondents we used the Pearson Chi-square test at the $P < 0.05$ significance level. All analyses were conducted using SYSTAT 12.0 (Systat Software, Inc., San Jose, California).

RESULTS

Surveys were returned from 496 of 774 hunters (64%). We received 64.6% of responses from the first mailing, 19.2% from the second mailing, and 16.2% from the final mailing. We obtained responses from 50 initial non-respondents. Respondents and non-respondents reported similar observations of moose ($\chi^2 = 0.000$, $P = 0.989$), and opinions about the trend of Connecticut's moose population ($\chi^2 = 3.2$, $P = 0.355$) and status of moose in Connecticut ($\chi^2 = 2.5$, $P = 0.483$) were similar. Respondents and non-respondents had similar opinions about whether the moose population warranted population control ($\chi^2 = 4.3$, $P = 0.118$). Due to similarities in responses between respondents and non-respondents, results were not adjusted for non-response bias.

Our deer hunting population was comprised of 97.1% males and 2.9% females with a mean age of 51.1 years (SD = 13.9). On average, respondents had 23.4 years (SD = 18.9) of hunting experience and most (90.9%, SE = 1.3) hunted in 2008. A quarter of the hunters (25.5%, SE = 2.0) had applied for a moose hunting permit in another state or province, and 10.5% (SE = 1.4) had hunted moose in another state or province. Hunters applied for moose permits in northern New England (88%), Canada (16%), the mid-west (3%) and Alaska (2%).

The deer management zone (DMZ) hunters primarily hunted deer in varied across Connecticut (Table 5.1). Thirteen percent (SE = 1.5) of hunters reported seeing moose in 32 different towns across Connecticut over a 30 year period (11 of 13 DMZ's) (Figure 5.1). In 2008, hunters observed 1 moose per 932 hunter-days spent afield. In northern DMZ's only (1, 2, 4a, and5) in 2008, hunters observed 1 moose per 612 hunter days spend afield.

Of hunters who reported observing a moose, a total of 111 moose sightings were reported between 1980 and 2009 (Figure 5.2). Most hunters were excited to see moose (84%), while few were concerned or uneasy (7%), or described their encounter as other (9%). Of hunters who observed moose during the hunting season, 41% (SE = 7.9) believed they had the opportunity to harvest it. Two percent (SE = 0.63) of hunters or someone in their household had been involved in a MVA (2 each in Connecticut, New Hampshire, Vermont, and 4 in Maine).

The majority of hunters (81.0%, SE = 1.8) believed the Connecticut moose population was between 10 and 499 moose, 9.4% (SE = 1.4) believed fewer than 10 moose existed in Connecticut, 5.2% (SE = 1.1) believed 500 or more existed in Connecticut, and 2.9% (SE = 0.8) had no opinion. The majority of hunters (66.5%, SE = 2.1) believed the moose population was increasing, 10.8% (SE = 1.4) believed it was stable, 1.2% (SE = 0.5) believed it was decreasing, and 21.4% (SE = 1.9) had no opinion. Nearly half of hunters (41.5%, SE = 2.2) believed the moose population was too low, 14.4% (SE = 1.6) believed the population was just right, 5.1% (SE = 0.9) believed it was too high, and 39.0% (SE = 2.2) had no opinion. Most hunters (62.7%, SE 2.2) were not concerned about the moose population expanding in Connecticut, 25.7% (SE = 1.5) were somewhat to slightly concerned, 6.7 (SE = 1.3) were very concerned, and 4.9% (SE = 1.0) had no opinion.

Based on hunters knowledge of the current moose population in Connecticut just over half of hunters (55.1%, SE = 2.3) supported using hunting as a method to control moose population growth, 20.7% (SE = 1.8) opposed hunting, 20.7% (SE = 1.8) were neutral, and 3.5% (SE = 0.8) had no opinion. If the moose population doubled, most hunters (75.8%, SE = 1.9) supported using hunting as a method to control moose population growth, 8.1% (SE = 1.2) opposed hunting, 13.0% (SE = 1.5) were neutral, and 3.1% (SE = 0.8) had no opinion. If the moose population tripled, most hunters (89.9%, SE = 2.1) supported using hunting as a method to control moose population growth, 2.5% (SE = 0.7) opposed hunting, 5.0% (SE = 1.0) were neutral, and 2.7% (SE = 0.7) had no opinion. Thirteen percent (SE = 1.5) of hunters felt the moose population in Connecticut warrants population control at the current time, 57% (SE = 2.3) did not believe it warranted control, and 30% (SE = 2.1) had no opinion.

If a hunting season was established, 43.6% (SE = 2.2) would prefer a restriction on the harvest of cow moose, 37.7 (SE = 2.2) would not, and 18.6 (SE = 1.8) had no opinion. If a hunting season were established, 59.9% (SE = 2.2) would prefer to have a special limited lottery permit system for moose, 30.5% (SE = 2.1) would not, and 9.6% (SE = 1.3) had no opinion. If a limited moose hunting season was established in Connecticut, 6.8% (SE = 1.1) of hunters would not pay anything to hunt moose, 42.8% (SE = 2.2) would pay between $1 and $40 to hunt moose, 20.7% (SE = 1.8) would pay between $41 and $80, and 29.8% (SE = 2.1) would pay more than $80,

If moose were common in Connecticut, 86.2% (SE = 1.5) would hunt moose, 51.2% (SE = 2.2) would go moose watching, 44.9% (SE = 2.2) would photograph moose, 1.6% (SE = 0.6) would participate in other moose-related activities, and 4.0% (SE = 0.8) would not participate in any moose-related activity. Forty-eight percent (SE = 2.3) of hunters would support designating wildlife viewing areas for moose, 32% (SE = 2.1) would not support designating wildlife viewing areas, and 20% (SE = 1.8) had no opinion.

If at some point moose population control was needed, hunters (n = 214) showed the greatest support (22%) for a statewide archery, firearms, and muzzleloader moose season using the current deer lottery system for state land and by written consent on private land. The second season with the greatest support (20.6%) was an archery-only season on private and state land in DMZ 1, 2, 4, and 5 following the current regulations for deer hunting. Lastly (20.1%) was a firearms-only season open statewide on private and state land set by the current lottery system on state land and with written consent on private land (Table 5.2).

DISCUSSION

Many Connecticut deer hunters have applied for moose permits or have hunted moose in various parts of the country and would be willing to pay for the opportunity to hunt moose in Connecticut if moose were common. Most hunters were knowledgeable about how many moose existed in Connecticut. However, hunters had no opinion about the status of the population or about how many moose should exist in the state. Using public opinion surveys in Montana, Riley and Decker (2000) found a large portion of people had no opinion about cougars. Riley and Decker (2000) suggested that lack of opinions may indicate a lack of concern about cougars, perceptions that managers do not listen, or trust in delegation of decision making to managers. Similar to Riley and Decker (2000), lack of hunter opinions in Connecticut was likely from the fact that nearly 13% thought <10 moose existed in Connecticut or were unsure how many existed and that only 13% of hunters had observed moose in Connecticut. If moose populations increase, it is expected that hunters will become more opinionated.

The areas where hunters spent their time hunting in Connecticut varied across the state. The majority of moose sightings reported by hunters occurred in northern Connecticut, which is consistent with previous findings (Kilpatrick et al. 2003, LaBonte et al. 2007, 2008, 2009). Similar to Kilpatrick et al. (2003), this study suggests that hunter sightings increased greatly from the 1980s to mid 2000s, indicative that Connecticut's moose population is experiencing growth. Frequency of moose sightings based on our survey in northern DMZ's (1 moose per 612 hunter-days spent afield in 2008) was similar to those based on the 2008 deer hunter survey (1 moose per 597 hunter-days spent afield, LaBonte et al. 2008). Sighting rates in Connecticut have been much lower than those in Massachusetts. Sighting rates at the Quabbin Reservoir in Massachusetts, which represents some of the best moose habitat in Massachusetts, were 1 moose per 6 hunter–days a field in 2006 (Massachusetts Department of Conservation and Recreation 2007). Sighting rates in Vermont are recorded by hunter hours and are therefore not comparable to Connecticut. However, hunter sighting rates in Vermont are used to develop moose population estimates and set management objectives (Alexander 2010). Sighting rates will be valuable in tracking changes in Connecticut's moose population in the future.

Moose-vehicle accidents are another valuable tool used to develop indices to monitor population trends (Alexander et al. 1993, Hicks 1993, Belant 1995). Human death and economic losses associated with MVA have been a concern throughout the northern hemisphere (Timmermann and Rodgers 2005). Connecticut hunters were involved in MVA while operating vehicles, but were not concerned about the moose population at the current level. The personal "value" of observing a moose in Connecticut may outweigh the concerns of hitting one with a motor-vehicle. The symbolic value of moose may be of significance, as the species is the largest living member of the cervid family and is relatively rare in comparison to other big game animals (Wolfe 1987). The value of moose sightings and MVA data may decline as populations increase and the novelty of observing moose declines, as noted with other species (S. Christensen, Massachusetts Department of Fisheries, Wildlife, and Law

Enforcement, M. Gregonis, Department of Energy and Environmental Protection, Wildlife Division, personal communication).

Similar to other areas throughout North America where restricted moose hunting seasons exist (Boyle et al. 1993, Alexander et al. 1998, Lenarz et al. 2009), half of all Connecticut deer hunters would prefer to have a restriction on the harvest of female moose or the issuance of permits, if a moose hunting season were to be established, presumably to conserve moose populations. Although the majority of survey respondents supported moose hunting, few believed the moose population in Connecticut warranted population control at the current time. However, if the moose population increased, support for moose hunting also would likely increase. Support for hunting was greatest for those potential seasons that were not restricted by the number of days. Managers should take into account preferences of hunters who would be affected by season timing, if there is flexibility as to when seasons could occur (Boyle et al. 1993). Kilpatrick et al. (2010) found that a large portion of hunters who would not support certain management strategies before they became legal, participated in the activity once it was legalized. A similar trend probably would occur as it relates to moose hunting, based on the interest hunters showed in moose.

From a traditional hunting perspective, it would not be a sound conservation decision to hunt moose whose existence in Connecticut is a relatively recent phenomenon. However, consideration will need to be given in regards to safety of residents, especially as it relates to MVA's. Educating hunters about the need for moose management needs to begin before the moose population reaches a level where human safety is compromised.

MANAGEMENT IMPLICATIONS

Development of successful management programs for moose in Connecticut will require strategies that are ecologically sound and supported by stakeholders that would manage moose. Strategies that allow for minimal take of animals so as to not compromise ecological integrity of the population, while minimizing the likelihood of animals dispersing into urban areas unsuitable for moose, will be difficult to develop. Deer hunter observations will be important in determining moose population density and distribution in states where populations are becoming established. However, because of hunter concerns linked to fears of overharvesting, state wildlife agencies will need to educate hunters. Under certain circumstances hunters may need to deviate from a more traditional mindset for the greater good of the species and human populations, threatened by increasing moose numbers. Managers should consider how hunter sightings will be beneficial for determining which areas should be opened to hunting, and hunter preference for season lengths and hunting methods.

Table 5.1. Distribution of hunters among 12 deer management zones based on the deer hunter survey, Connecticut, USA, 2008.

	Percent of Deer Hunters
Zone most hunted	
1	7.9
2	10.5
3	6.6
4a	6.4
4b	3.6
5	12.0
6	6.2
7	6.4
8	9.0
9	7.7
10	6.4
11	9.4
12	7.9

Table 5.2. Percent of hunters who ranked different moose hunting seasons as the most supported if population control was warranted (either sex tags provided at no additional cost) on the deer hunter survey in Connecticut, USA, 2008.

% of hunters	Season	Area Open (Deer Management Zone =DMZ)	Season Limitations	Hunting Days
20.6	Archery	Private and State land in DMZ 1, 2, 4, & 5	Open on state land where archery hunting is permitted & with written consent on private land	92
4.2	Firearms	State land only in DMZ 1 and 2	Set by current deer lottery system for state land	2
6.5	Firearms	Private and State land in DMZ 1 and 2	Set by current deer lottery system for state land & with written consent on private land	2
12.1	Firearms	Private and State land in DMZ 1, 2, 4, & 5	Set by current deer lottery system for state land & with written consent on private land	2
10.3	Firearms	Open on Private and State land **"statewide"**	Set by current deer lottery system for state land & with written consent on private land	2
20.1	Firearms	Open on Private and State land **"statewide"**	Set by current deer lottery system for state land & with written consent on private land	18
4.2	Archery Firearms Muzz.	Open on Private and State land in **all zones except DMZ 1, 2, 4, & 5**	Set by current deer lottery system for state land & with written consent on private land	122
22.0	Archery Firearms Muzz.	Open on Private and State land **"statewide"**	Set by current deer lottery system for state land & with written consent on private land	122

Figure 5.1. Density and distribution of moose sightings collected from the 2008 deer hunter survey in Connecticut, USA, 1980–2009.

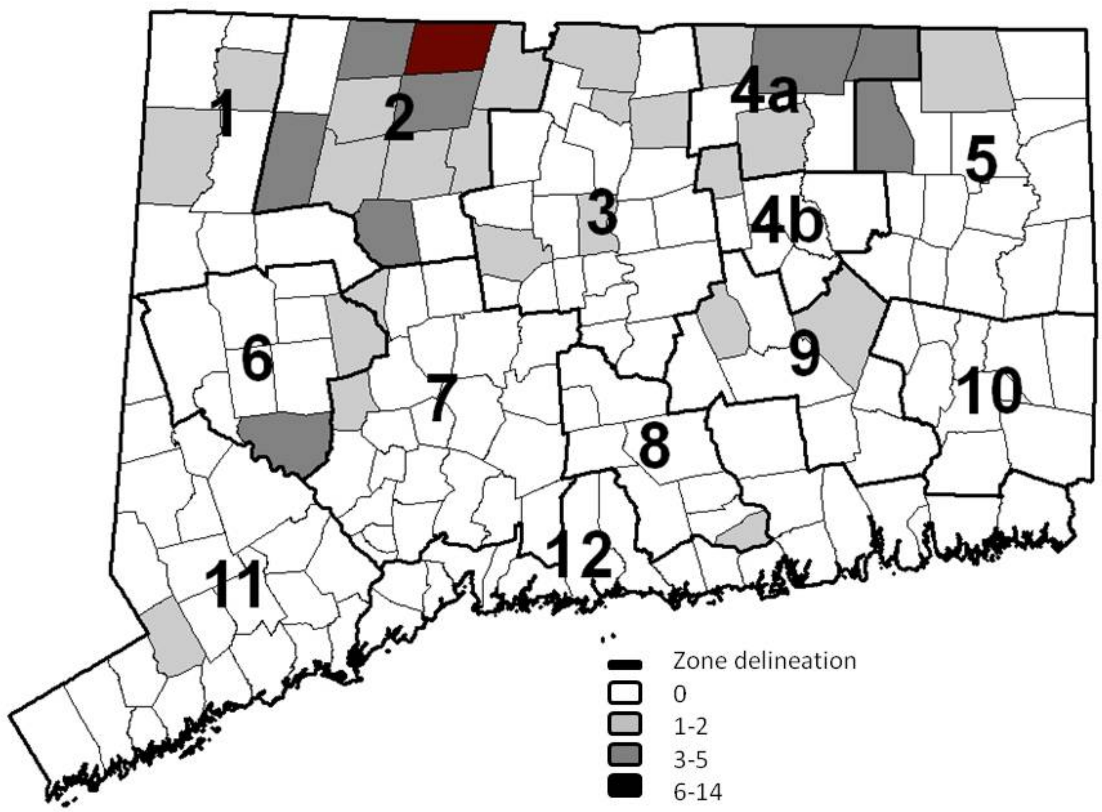
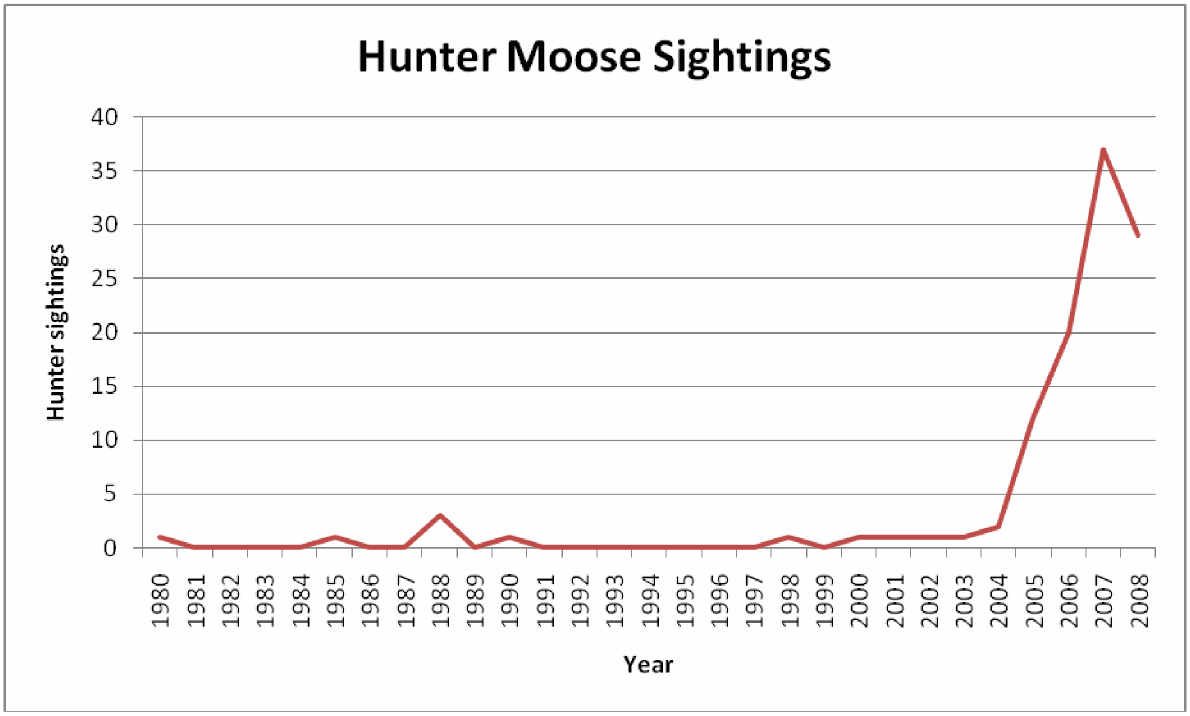


Figure 5.2. Distribution of hunter moose sightings collected from the 2008 deer hunter survey in Connecticut, USA, 1980–2009.



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CHAPTER 6

KEY FINDINGS AND RECOMMENDATIONS

Agency concerns associated with expanding moose populations at the southern extent of moose range have prompted the need to evaluate factors that may affect population increases and future range expansion, and identify potential management strategies. The goal of this study was to identify areas of Connecticut that were most suitable for moose, predict where expansion could occur, estimate the current population size and how quickly that population may expand over time, and develop innovative and effective strategies for managing the moose population. These strategies incorporated both social and biological factors. This chapter highlights important findings and recommendations from the study.

Habitat and Population Growth

Habitat and temperature were both limiting factors restricting moose population expansion in Connecticut. It is unlikely, based on limited landscape suitability that a successful breeding population of moose will expand outside the areas they currently occupy. Temperature may be a major environmental variable limiting moose at the southern extent of their range and is something that can't be controlled. However, percent area in small diameter trees was also a limiting variable for moose. Increasing the amount of area in small diameter trees is a recommendation of the DEEP Forestry Division to provide greater diversity across Connecticut's landscape. Increasing the amount of early successional habitat by intensively managing the forests in northern Connecticut will benefit many species listed by the DEEP as species of greatest conservation need such as: New England cottontail (*Sylvilagus transitionalis*), American woodcock (*Scolopax minor*), and ruffed grouse (*Bonasa umbellus*) as well as moose. Creating more early successional habitat in areas currently occupied by moose may limit overwinter stress on females, improving survival, reproductive performance, and ultimately population growth. However, the magnitude of these forestry practices may benefit few moose and likely will have little impact on changing the distribution of moose in the state. Evaluating the effects of elevation on landscape suitability for moose would be beneficial as would capturing and marking animals to better evaluate population growth, home range size, habitat use, and causes of mortality in Connecticut.

Education

Moose have been present in the state for more than a decade, however some landowners were unaware of their existence. Efforts should be made to educate residents about moose in Connecticut. Developing an informational brochure, booklet, or more developed online page containing information about moose and moose management would be beneficial in increasing public awareness. Providing talks for local residents at conservation commission, land trust meetings, and at other venues will not only inform residents that moose exist, it will also provide an opportunity to discuss the benefits and disadvantages of having moose in a state as urbanized as Connecticut. If the moose population continues to grow and expand, more emphasis may be placed on the importance of developing and implementing an active management plan before moose become a major hazard to Connecticut residents. Of landowners who were aware moose existed, their greatest concern was being involved in a moose-vehicle accident (MVA). Although few MVA's occur each year in Connecticut, efforts should be made to provide residents with information that will be beneficial for their safety. In circumstances when moose are known to be traversing through urban areas of the state, it would be beneficial to send out a press release and post warning information on variable message boards located on highways informing motorists of the potential dangers.

Management

Landowners and hunters in Connecticut were supportive of managing the moose population. In areas where moose currently exist in northern Connecticut, the majority of landowners would be supportive of establishing a moose hunting season provided a minimum of 2 moose-vehicle accidents occur annually and hunting was carefully regulated by the state. At this time both of those criteria are being meet. If the number of accidents increases or a single human fatality occurs annually, support for managing the moose population would only increase. On the other hand, hunters were supportive of hunting moose but preferred the see the moose population to increase. Hunters being mainly an environmentally conscious group, would prefer limiting the harvest of females and the number of permits that would be issued if a moose hunting season was established. Efforts should be made to educate hunters about the need to manage moose populations for public safety reasons as opposed to recreational use of a natural renewable resource. A conservative approach might be to allow hunting of moose outside northern Connecticut, where limited suitable habitat exists and where human-moose conflicts are likely to occur, while still allowing for potential population growth to occur in northern Connecticut.

Appendix A. Survey instrument used to query landowners in Connecticut, 2008.

1) The following statements reflect different beliefs or experiences people have about wildlife. Please indicate the extent to which you **agree** or **disagree** with each. (*Please circle one response for each statement.*)

	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Don't know**
I notice birds and wildlife around me daily.	1	2	3	4	5	6
Observing and learning about wildlife is important to me.	1	2	3	4	5	6
Hunting animals for any purpose should not be permitted.	1	2	3	4	5	6
It is important to manage some wild animal populations.	1	2	3	4	5	6
Wild animal populations should be managed for the benefit of all people.	1	2	3	4	5	6
Participation in hunting helps people appreciate wildlife and natural processes.	1	2	3	4	5	6
If wildlife populations are abundant, it is ok to use them as a natural renewable resource.	1	2	3	4	5	6
Regulated hunting is an acceptable use of a natural resource	1	2	3	4	5	6

2) Please indicate how often you participate in any of the following outdoor activities?

Activity	**Circle one for each activity** (NA = NOT APPLICABLE)				**Activity**	**Circle one for each activity** (NA = NOT APPLICABLE)			
Fishing	NA	Weekly	Monthly	Annually	**Camping**	NA	Weekly	Monthly	Annually
Wildlife viewing	NA	Weekly	Monthly	Annually	**Hiking/Walking**	NA	Weekly	Monthly	Annually
Feeding birds/ Wildlife	NA	Weekly	Monthly	Annually	**Hunting**	NA	Weekly	Monthly	Annually
Biking	NA	Weekly	Monthly	Annually	**Other Outdoor Rec.**	NA	Weekly	Monthly	Annually

3) Please circle the animal that you believe best represents an image of a moose (circle one only)?

4) How many **Moose** do you believe **currently live in Connecticut**?

0 **<10** **<100** **100–499** **500–1,000** **>1,000**

5) What was your **primary source** of information leading to your estimate about how many moose reside in Connecticut (Circle only one response)?

CT Wildlife Magazine **Newspaper** **TV** **Radio** **Personal Experience** **Other___________**

6) What is your opinion about the status of **Connecticut's Moose** population?

Increasing **Decreasing** **Stable** **No opinion**

7) What is your opinion about the **number of moose** in Connecticut?

Too High **Too Low** **Just Right** **No Opinion**

8) How many moose have you personally observed **in Connecticut the past 2 years (2006/2007)**?

In your back yard:	0	1-3	4-6	7-9	> 10	TOWN____________
Crossing a road:	0	1-3	4-6	7-9	> 10	TOWN____________
Outside your yard:	0	1-3	4-6	7-9	> 10	TOWN____________
Other_____________:	0	1-3	4-6	7-9	> 10	TOWN____________

If you observed moose in the past 2 years, how would you describe your encounters with **Moose in Connecticut**?

Exciting **Uneasy/Concerned** **Other_____________________** **No opinion**

9) If you have not personally observed a moose in Connecticut, have you ever seen **moose tracks** or **other evidence** of **Moose in the past 2 years (2006/2007)**?

Yes **No** **Unsure** **If yes, which towns_____________________________________**

10) Which of the following activities, if any, would you participate in if moose were common in Connecticut? (Circle all that apply)

Moose Watching **Photographing Moose** **Hunting Moose** **Other** **None**

11) Would you support designating wildlife viewing areas for moose watching?

Yes **No** **Unsure**

12) Have you ever been involved in a moose-vehicle accident in **Connecticut or any other state**?

Yes **No** **If yes, where: Town, State______________________________**

13) How concerned are you personally about the following issues or experiences relating to **Moose in Connecticut** (Circle one response for each statement).

	Not concerned	**Slightly concerned**	**Somewhat concerned**	**Very concerned**	**Unsure**
Encountering a moose while outdoors.	1	2	3	4	5
The cost of residential property damage caused by moose.	1	2	3	4	5
Being injured in a motor vehicle accident that involves a moose.	1	2	3	4	5
Potential problems that moose may cause to the ecosystem.	1	2	3	4	5

14) **Overall,** how would you rank your **current level of concern** relating to moose?

Not Concerned | Slightly Concerned | Somewhat Concerned | Very Concerned | Unsure

15) Do you support or oppose **using hunting** as a method to control moose populations in Connecticut: (**Circle one response for each statement).**

	Strongly support	**Support**	**Neutral**	**Oppose**	**Strongly oppose**	**No opinion**
Based on your **current level of concern?**	1	2	3	4	5	6
If your level of concern **increases?**	1	2	3	4	5	6
If hunting was **carefully regulated and controlled by the state?**	1	2	3	4	5	6
If you knew that the Moose population would be **maintained at its current level?**	1	2	3	4	5	6
If you knew that hunting is **currently allowed in other New England states** (New Hampshire, Vermont, and Maine)?	1	2	3	4	5	6
If you knew the likelihood of a **human fatality was greater for a moose-vehicle accident** than a deer-vehicle accident and that the moose population and number of moose-vehicle accidents was increasing in Connecticut?	1	2	3	4	5	6

16) If you indicated you **primarily supported hunting** to control **Moose** populations on the previous question (#14), why? **(CHECK ALL THAT APPLY AND RANK THEM ON A SCALE OF 1 – 8, 1 BEING MOST IMPORTANT, 8 BEING LEAST IMPORTANT)**

______Moose population is too high or may become to high
______Moose threaten human safety
______Moose cause damage to crops or property
______Regulated hunting is a legitimate method to control Moose population growth
______DEEP officials are well trained to handle problems associated with moose
______Want the opportunity to hunt Moose
______Don't know
______Other__________________

17) If you indicated you **primarily opposed** hunting to control **Moose** populations on the previous question (#14), why? **(CHECK ALL THAT APPLY AND RANK THEM ON A SCALE OF 1 – 8, 1 BEING MOST IMPORTANT, 8 BEING LEAST IMPORTANT)**

______Moose population is too low and does not warrant management
______Moose are not a threat to human safety at their current level
______Moose do not cause enough damage to warrant management
______Disagree with hunting
______Do not support hunters killing moose
______Do not support DEEP killing moose
______Don't know
______Other__________________

18) If you indicated you opposed hunting to control Moose populations on the previous question (#14), please rank the following options on a scale of 1 – 6, that would be acceptable alternatives to you (**1 BEING MOST ACCEPTABLE, 6 BEING LEAST ACCEPTABLE)**

______Trap and relocate within state
______Trap and kill
______Use sharpshooters under strictly controlled setting
______Birth Control
______No action
______Other__________________

19) Please circle the number that represents your acceptability of each situation involving a **Moose in Connecticut** as described below (Circle one response for each statement).

Situation	*Acceptable but no action should be taken*	*Somewhat Acceptable but no action should be taken*	*Not acceptable but no action should be taken*	*Not acceptable and should trap and relocate regardless of cost*	*Not Acceptable and would agree to allow state to remove problem animals*	*Not Acceptable and would agree to using hunting to control population growth and future problems*
A moose is on or near a busy highway occasionally	1	2	3	4	5	6
Moose are frequently on or near busy highways	1	2	3	4	5	6
1 moose-vehicle collision occurs each year statewide	1	2	3	4	5	6
2-5 moose-vehicle collisions						

occur each year statewide	1	2	3	4	5	6
6-10 moose-vehicle collisions occur each year statewide	1	2	3	4	5	6
>10 moose-vehicle collisions occur each year statewide	1	2	3	4	5	6
A human fatality results from a motorists hitting a moose in Connecticut	1	2	3	4	5	6
2-5 human fatalities result from motorists hitting moose in Connecticut	1	2	3	4	5	6
6-10 human fatalities result from motorists hitting moose in Connecticut	1	2	3	4	5	6
>10 human fatalities result from motorists hitting moose in Connecticut	1	2	3	4	5	6

20) Please rank your sources **for news** regarding **wildlife and the environment**? (0 = No source, 1 = most important, 11 = least important)

News Source	Rank	News Source	Rank	News Source	Rank	News Source	Rank
Local Newspapers		Regional Papers		Television		DEEP website	
Radio		Magazines		Internet		Conversation with friends	
CT Wildlife Magazine		Presentations		Other________			

21) How long have you lived at the current address?____Years. 22) Reside at address year round YES NO

23) Which area best describes the area where you live? (Circle one)

(Many neighbors/little forest) (Neighbors/forest) (Few neighbors/much forest)

24) Which characteristics best describe your property? (Circle one answer for each)

a. Maintained lawn only	Yes	No	b. Farmland/Cropland	Yes	No
c. Land with active forest mgmt practices	Yes	No	d. Some hunting occurs on property	Yes	No
e. Undeveloped lots not actively managed	Yes	No			

25) What year were you born? 19___ 26) What is your gender? Male Female

Please contact the Connecticut Wildlife Division at the address below if you are interested in receiving more information about moose or receiving a copy of the results from this survey when completed.

Please provide any additional Comments on the back of this page

Appendix B. Survey instrument used to query hunters in Connecticut, 2008.

1) Circle all species you have **hunted for in any state in the last 5 years.**

Moose **Deer** **Bear** **Waterfowl** **Turkey** **Small Game** **OTHER**

2) Approximately how many days per year do you spend participating in the following outdoor activities?

Hunting _______ days Fishing _______ days Wildlife Viewing _______ days

Camping _______ days Hiking/Walking _______ days Other outdoor activities _______ days

3) How many **Moose** do you believe **<u>currently reside in Connecticut</u>**?

0 **1 – 10** **11 – 99** **100 – 499** **500 – 1,000** **>1,000**

4) What was your **primary source** of information leading to your estimate about how many moose reside in Connecticut (Circle only one response)?

CT Wildlife Magazine **DEEP Communication** **Newspaper** **TV**

Friends/Relatives **Radio** **Personal Experience** **Other**_______________________________

5) Do you think **Moose** populations **in Connecticut** are increasing, decreasing, or stable?

Increasing **Decreasing** **Stable** **No Opinion**

6) In your opinion, would you say the **Moose** population **in Connecticut** is too high, too low, or just right?

Too High **Too Low** **Just Right** **No Opinion**

7) How many moose have you **personally** observed **in Connecticut the past 2 years**?

In your back yard:	0	1-3	4-6	7-9	> 10	Town_____________
Crossing a road:	0	1-3	4-6	7-9	> 10	Town_____________
While hunting or enjoying nature outside your yard:	0	1-3	4-6	7-9	> 10	Town_____________
Other______________________:	0	1-3	4-6	7-9	> 10	Town_____________

If you observed moose in the past 2 years, how would you describe your encounters with **Moose in Connecticut**?

Exciting **Uneasy/Concerned** **No opinion** **Other**________________________

8) If you **have not personally observed** a moose in Connecticut, have you ever seen **moose tracks** or **other evidence** of **Moose in the past 2 years**?

Yes **No** **Unsure** **If yes, which towns**___________________________

9) Which of the following activities, if any, would you participate in if moose were common in Connecticut? (Circle all that apply)

Moose Watching   **Photographing Moose**   **Hunting Moose**   **Other**   **None**

10) Would you support or oppose hunting to control moose populations in Connecticut: (Circle one response for each statement).

	Strongly Support	**Support**	**Strongly Oppose**	**Oppose**	**Neutral**	**No Opinion**
If hunting was **carefully regulated and controlled by the state?**	1	2	3	4	5	6
If you knew that the Moose population would be **maintained at its current level?**	1	2	3	4	5	6
If you knew the moose population and number of moose-vehicle accidents was increasing in Connecticut and the likelihood of a **human fatality was greater for a moose-vehicle accident** than a deer-vehicle accident?	1	2	3	4	5	6

11) What year were you born? 19___

12) What is your gender?   M**ale**   **Female**

13) Are you affiliated with any hunting organization in Connecticut?

Yes   **No**

14) Are you interested in receiving more information about moose, (If so Please provide contact information below or contact the Connecticut Wildlife Division)?

Yes   **No**

Additional
Comments:____
____
____

Sincerely,

Andrew LaBonte
Connecticut Wildlife Division
391 Route 32
N. Franklin, CT 06238
860-642-7239
andrew.labonte@po.state.ct.us

Appendix C. Survey instrument used to query deer hunters in Connecticut, 2008.

1) Circle all species you have hunted for in any state in the last 5 years.

Moose Deer Bear Waterfowl Turkey Small Game Other

2) How many years have you been hunting deer in **Connecticut**? __________Years

3) Did you hunt deer in 2008? YES NO

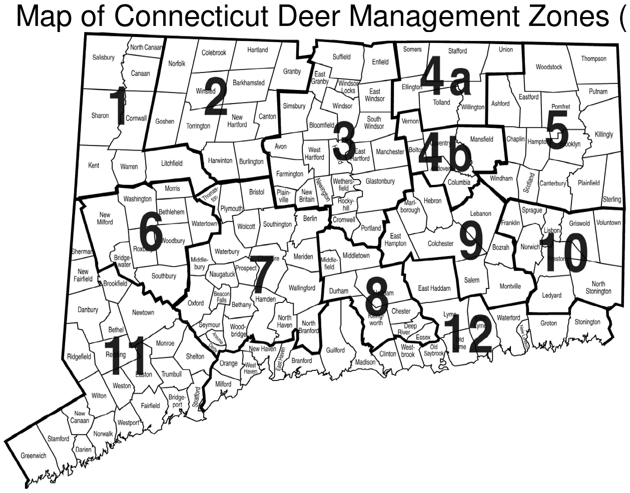
4) If you hunted deer in 2008, indicate what **seasons** you hunted and write the **approximate number of days spent hunting** during each season? (Circle season, enter days)

Season	Total Available Days in 2008	Days spent Hunting
Archery	92	
Archery (January Season)	27	
Private Land Shotgun/Rifle	18	
State Land Shotgun/Rifle (A Season)	18	
State Land Shotgun/Rifle (B Season)	18	
Private Land Muzzleloader	12	
State Land Muzzleloader	12	
Landowner	52	

5) Which **zone** on the map below do you **primarily** hunt in? (Circle only one)

1 2 3 4a 4b 5 6 7 8 9 10 11 12

Map of Connecticut Deer Management Zones (DMZ's)



6) Have you ever observed a moose **(Do not include tracks or sign) in Connecticut**? (if additional space is needed please put information on the back of the survey)

YES **NO** **UNSURE** **IF yes, please provide details in table below:**

YEAR	# OF MOOSE	TOWN(S)	TYPE OF ACTIVITY (ie. hunting, driving)

If you observed moose, how would you describe your encounters with **Moose in Connecticut**? (Circle all that apply)

Exciting **Uneasy/Concerned** **Other______________________** **No opinion**

If you observed a moose while hunting, did you have the **potential to harvest the moose**?

YES **NO** **If yes, (Circle season)** **ARCHERY** **SHOTGUN** **MUZZLELOADER**

7) If you have not personally observed a moose in Connecticut, have you ever seen **moose tracks** or **other evidence** of **moose in Connecticut?**

YES **NO** **UNSURE** **If yes, what type of sign, and which towns________________________**

8) Have you applied for a moose permit or hunted moose in another State or Province? (Circle all that apply)

Applied for a moose permit: **YES** **NO** **States/Province____________________________**
Hunted moose: **YES** **NO** **States/Province____________________________**

9) How many **Moose** do you believe **currently exist in Connecticut**?

0 **<10** **10–99** **100–499** **500–1,000** **>1,000**

10) What was your **primary source** of information leading to your estimate about how many moose reside in Connecticut? (Circle only one response)

State Agency **Internet** **Newspaper** **TV** **Radio** **Personal Experience** **Other__________**

11) What is your opinion about the status of **Connecticut's Moose** population? (Circle only one response)

Increasing **Decreasing** **Stable** **No opinion**

12) What is your opinion about the current **number of moose** in Connecticut? (Circle only one response)

Too High **Too Low** **Just Right** **No Opinion**

13) Have you or anyone in your household ever been involved in a moose-vehicle accident in **Connecticut or any other state**?

YES **NO** **UNSURE** **If yes, where? Town, State____________________________**

14) How concerned are you about the moose population expanding in Connecticut? (Circle only one response)

Not Concerned **Slightly Concerned** **Somewhat Concerned** **Very Concerned** **Unsure**

15) Do you support or oppose **using hunting** as a method to control moose population growth in Connecticut: (**Circle one response for each statement).**

	Strongly support	**Support**	**Neutral**	**Oppose**	**Strongly oppose**	**Don't know**
Based on your knowledge about the current population?	1	2	3	4	5	6
If the current population doubled?	1	2	3	4	5	6
If the current population tripled?	1	2	3	4	5	6

16) Do you feel the moose population in Connecticut warrants population control **at the current time**? (Circle one)

YES **NO** **UNSURE**

If at some point population control is needed, please rank the following hunting strategies based on your support (**EITHER SEX MOOSE TAGS PROVIDED AT NO ADDITIONAL COST**)? (Please rank strategies from 1-8; 1 being most supported, 8 being least supported, using each number only once) (Refer to zone map on page 1 if needed)

Rank	**ID**	**Season**	**Area Open (Deer Management Zone =DMZ)**	**No of hunters**	**Hunting Days**
	1	Archery	Private and State land in DMZ 1, 2, 4, & 5	Open on state land where archery hunting is permitted & with written consent on private land	Entire archery season
	2	Firearms	State land only in DMZ 1 and 2	Set by current deer lottery system for state land	2
	3	Firearms	Private and State land in DMZ 1 and 2	Set by current deer lottery system for state land & with written consent on private land	2
	4	Firearms	Private and State land in DMZ 1, 2, 4, & 5	Set by current deer lottery system for state land & with written consent on private land	2
	5	Firearms	Open on Private and State land **"statewide"**	Set by current deer lottery system for state land & with written consent on private land	2
	6	Firearms	Open on Private and State land **"statewide"**	Set by current deer lottery system for state land & with written consent on private land	Entire deer Season
	7	Archery Firearms Muzz.	Open on Private and State land in **all zones except DMZ 1, 2, 4, & 5**	Set by current deer lottery system for state land & with written consent on private land	Entire deer Season
	8	Archery Firearms Muzz.	Open on Private and State land **"statewide"**	Set by current deer lottery system for state land & with written consent on private land	Entire deer Season
			PROVIDE AN ALTERNATIVE	**RECOMMENDATION HERE**	

17) In the hypothetical seasons listed in Question 16 above, tags would be of either sex. If a moose hunting season was established, would you **prefer a restriction** on the harvest of **cow moose**?

YES **NO** **NO OPINION**

18) Instead of having the moose season open to everyone, would you prefer to have a **special limited permit lottery** system just for moose?

YES **NO** **NO OPINION**

19) Please circle the number that represents the maximum amount of money you would pay to obtain a moose permit, if a limited moose hunting season was established in Connecticut (Circle one only).

$0 **$1-20** **$21-40** **$41-60** **$61-80** **$81-100** **>$100**

20) If you feel the moose population **does not warrant population** control at this time, please specify why.

____

____

21) Which of the following activities, if any, would you participate in if moose were common in Connecticut? (Circle all that apply)

Watching Moose **Photographing Moose** **Hunting Moose** **Other** **None**

22) Do you support designating wildlife viewing areas for moose watching? (Circle one)

YES **NO** **UNSURE**

23) What year were you born? 19___ 24) What is your gender? Male Female

25) Please indicate your highest level of education (Circle one).

High School 9 10 11 12 GED Associates Bachelors Graduate level or higher

Please contact the Connecticut Department of Energy and Environmental Protection if you are interested in receiving more information about moose or receiving a copy of the results from this survey when completed.

Please provide any additional Comments:____

____

____

____